GOLDEN JUBILEE CELEBRATIONS

Souvenir 2000

Issued at the National Symposium on Eco - Friendly Mariculture Technology Packages - An Update, held at Mandapam Camp, 25 - 26 April 2000 to mark the Golden Jubilee Celebration of Staff Recreation Clubs

MANDAPAM REGIONAL CENTRE OF CENTRAL MARINE FISHERIES RESEARCH INSTITUTE MARINE FISHERIES POST - 623 520, MANDAPAM CAMP RAMANATHAPURAM DISTRICT, TAMIL NADU, INDIA

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FOREWORD

The Marine Biological Association of India, established in 1958, enjoys an unique position among organisations of its kind with diverse activities in communicating research outputs in the field of marine biology, oceanography, fish & fisheries and aquaculture from within the country and abaroad. The Association's Journal has acclaimed international reputation by virtue of the variety and quality of scientific papers, the deep commitments to science and the regularity of its publication. Another noteworthy contribution of the Association is the conduct of International Symposia on subjects of topical interest and national and global relevance from time to time and the publication of their proceedings. The scientific richness, organising capabilities, regularity of publications, all of which have elevated the Association to a high pedestal with the wholehearted interest, support, collaboration and cooperation of its institutional, national and international members. It is gratifying to note that the scientific/technical staff of Central Marine Fisheries Research Institute, a premier Institution for R & D in Marine Living Resources, under a wide and prestigious umbrella of ICAR, has contributed substantially to the growth of the Association at all times purely on a voluntary and honorary capacity. The Symposium on **'Ecofriendly Mariculture Technology Packages - An Update'** is the 9th in a series of International Symposia visualised, planned, organised and conducted by the Association.

A Souvenir is being brought out on the occasion of this Symposium. The Souvenir carries the R & D activities and technological excellances of CMFRI. I am glad to note that many have offered thematic and general articles to enrich the Souvenir. The gesture of many Institutions and firms who have come out with their advertisements is an added attraction to support the venture and the cause. I assure that the C.M.F.R. Institute will continue its support to popularise marine science and to march ahead in the right direction to supplement marine fish production through more and more new state of the art technology packages in the years to come.

K.GOPAKUMAR
Deputy Director General (Fisheries),
Indian council of Agricultural Research,
Krishi Bhawan, New Delhi - 110 001.

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A.C.C. Victor,
Regional Centre of Central Marine Fisheries Research Institute, Marine Fisheries - 623 520, Ramnad District, Tamil Nadu.

The Mandapam Regional Centre of Central Marine Fisheries Research Institute at Mandapam Camp is one of the Premier Institutions for R&D in the field of Marine Fisheries Research and is an advanced centre of its kind among the subordinate establishment of Central Marine Fisheries Research Institute. It is located on an impressive and picturesque elevated sand dune spread over 84 acres overseeing the Palk Bay in the north and Gulf of Mannar in the south. The history of the Centre dates back to 1943. The proposal for establishing various Central Fisheries Research Institutes, under the Union Government, was first made in 1943. The Fish Sub Committee of the Policy Committee on Agriculture and Fisheries in its report in 1945 endorsed this proposal. Subsequently on the basis of the "Memorandum on the proposed Fishery Research Institute" submitted by Lt. Col. R.B. Seymour Sewell in 1946, the Central Marine Fisheries Research Institute (CMFRI) came into existence on the 3rd February 1947 at the Zoology Laboratory building of the Madras University. The establishment was later shifted to Mandapam Camp in 1949 where it was housed in the Naval Building Complex, which was acquired in 1946 and modified into laboratories, administrative wings and temporary residential accommodation.

Since then, the establishment at Mandapam Camp functioned as Headquarters of the Institute for more than 2 decades before being shifted to Cochin in the year 1971. The main function of the Institute was to assess and monitor the status of exploited and unexploited fish stocks in the EEZ, development of suitable techniques for sea farming of finfish, shellfish, seaweed and other cultivable marine organisms. After shifting the headquarters of the Institute to Cochin, the establishment at Mandapam Camp was renamed as Regional Centre of CMFRI and attained the status next to Headquarters. The calm, serene, shallow, unpolluted seawater of the Palk Bay and Gulf of Mannar not only exemplies the biological significance of the area but also offer an ideal background for carrying out Research and Development on marine fisheries.

Laboratories

The Regional Centre has a strong R&D base with well equipped laboratory facilities for undertaking research on the biology, ecology, physiology, pathology and culture of marine organisms, analysis of seawater and studies on primary and secondary production. The laboratories are equipped with many facilities which include compound microscopes, binocular microscopes, refrigerators, hot air ovens, incubators, spectrophotometers, calorimeters, pH meter and autoclaves. An air-conditioned microalgae culture laboratory has been set up in which seven species of commercially important microalgae are maintained as stock culture. Chemistry and biotechnology laboratories have also been recently developed.

Hatcheries and rearing facilities

A shrimp hatchery with a production capacity of 2 million postlarvae of ***Penaeus semisulcatus/P. monodon*** per year is available in the sourthern side of the aquarium. A small crab hatchery has been developed adjacent to the shrimp hatchery. An indoor pearl oyster hatchery with a capacity to produce 20 million

spat per year has been established by converting the existing building of the fishery biology block. The hatchery is likely to be extended further adjacent to the present hatchery. Eight onshore tanks of 100 ton capacity each, have also been developed for nursery rearing of pearl oyster spat and broodstock maintenance of grouper. A green house with seawater facility is also available.

Museum and Aquarium

The marine museum of the centre is one of the biggest museums in the Southeast Asia. It houses an enormous collection of fishes and other fauna and flora of economic and zoological importance from the seas around India, including Andaman & Nicobar and Lakshadweep Islands. There are about 1100 species of fishes, 152 sponges,180 corals, 200 tube dwelling worms, 220 crabs and hermit crabs, 125 prawns stomatopods and 370 sea shells displayed and exhibited in the museum. An all glass aquarium with running seawater facility is available to maintain different species of live ornamental fishes, coelenterates, crustaceans and molluscs. Outdoor cement tanks are available for the maintenance of turtles and other marine animals.

Library

The Regional Centre has a well-equipped library to cater the needs of all those establishments/Institutions engaged in Research and Development in India. It is one of the best libraries in the whole of South-East Asia for literature on Aquatic sciences in general and fisheries in particular. The library has over 10,000 volumes of books, monographs, periodicals and reports and 30,000 scientific journals. It subscribes for 15 foreign and 50 Indian journals besides receiving 150 periodicals on exchange or complimentary basis. The library possesses some of the rare and old publications on marine sciences and fisheries, expeditions and survey reports that are not available in any other libraries within the country. It has documentation and reprographic facilities too.

Field Laboratory and Fish Farm

The Centre has established a field laboratory and a marine fish farm in about 3.8 ha area adjoining the Palk Bay for mariculture activities. Twenty eight culture ponds with provision for seawater supply have been developed for experimental culture of fishes and prawns. Besides, a small lagoon of about 200 ha area is available for carrying out experimental studies on tropical lagoon ecosystem.

Buildings

The Regional Centre is housed in the Institute's own buildings in an area of 140 ha. The residential accommodation comprised of old and new colonies is available and the staff members are provided with family type quarters and bachelor accommodation. A Guest House is also available for providing accommodation to visiting dignitaries and scientists.

Other facilities

The Centre has a Research vessel MV Sagitta (9.8m OAL) for collection of hydrographic and plankton data from the inshore waters of Mandapam and for carrying out experimental fishing. The Centre is supported with one jeep and a tempo van for its programmes connected with field work. Besides, there is a workshop and a carpentry unit to look after the civil and electrical repair works. Two generators 70 KV and 50 KV are available to maintain the uninterrupted power supply. The centre is recognised by several universities as a nodal Centre for post graduate research leading to M.Sc. and Ph.D. degrees in marine sciences.

Manpower

The regional centre has a total strength of 141 staff which includes 12 scientific, 41 technical, 16 administrative and 72 supporting personnel.

Research activities

Zonal wise assessment and monitoring of exploited marine fish production and their dynamics in Thanjavur, Pudukottai and Ramanathapuram districts of Mandapam Regional Centre which helped to elevate the significant fishery of considerable magnitude and improved socio-economic status of coastal rural population.

Investigations on the fishery, biology and resource characteristics of all major exploited finfishes, crustaceans and molluscs around Mandapam and Rameswaram regions and studies on stock assessment.

Studies on the hydrology of Gulf of Mannar and Palk Bay sea ; estimation of primary and secondary production and their inter-relationship in the food chain at various tropic levels paving way for estimation of potential fishery resources of the sea.

Development of hatchery techniques for mass production of the seed of marine prawns, crabs, and gastropod molluscs (Sacred chank) under controlled conditions and their sea ranching.

Development of suitable technologies for mass production of pearl oyster seed, farming of pearl oysters in the offshore and onshore facilities , production of cultured pearls, evaluation of techno-economics of pearl culture and upgradation of pearl culture through R&D in Bio-technoogy.

Development of technologies for broodstock management, induced maturation, breeding and seed production of groupers, seabass, rabbitfish and ornamental fish under controlled conditions.

Investigations on seaweed resources, their exploitation, culture, genetic improvement and extraction of agar, alginic acid and other products enabling promotion of seaweed industry in the region.

Studies on the nutritional quality and development of diet and optimisation of feeding regimes for cultivable crustaceans, finfishes and pearl oysters. Mass production of live feed organisms for feeding different larval stages of prawn and fishes by standardising the techniques and mass culture of ***Chlorella*** spp., ***Isochrysis*** spp., diatoms and dinoflagellates as feed for the live feed organisms and pearl oyster spat.

Pathological investigations in marine finfish and shellfish and treatment in the aquaculture system.

Transfer of viable seafarming technologies through extension education, training and consultancy services.

The above research activities are carried out under 25 research projects of which 11 programmes are carried out in the field of Mariculture and the rest under capture fisheries relating to assessment and monitoring of the exploited stocks. Besides this, two ICAR revolving fund projects and two DBT sponsored R&D projects are also in operation.

Research Achievements

Capture fisheries

The ongoing research projects on finfish and shellfish resources are directed to determine the population characteristics and their dynamics to assess the stock status of the resources to advise their rational exploitation. In this connection, fluctuations in the seasonal and annual production of pelagic resources such as sardines, anchovies, mackerel and seerfishes and demersal resources such as elasmobranchs, perches, silverbellies, threadfin breams, croakers, flatfishes and goatfishes and certain biological characteristics have been studied.

The shark which is an important demersal resource of Mandapam region contributing an annual yield of about 1500 to 2500 tonnes.

Silver bellies are the dominant demersal fishery resource of Mandapam region, useful in fish meal industry. The estimated annual average landings are about 18500 tonnes.

Researches have shown that the larger penaeid species like ***Penaeus semisulcatus*** and ***P. indicus*** could sustain an annual yield of 2000 to 3000 tonnes. The study has further revealed the changing scenario in the species composition of prawns in the area. The organised fishery for juveniles of ***P. semisulcatus*** along the Palk Bay in depth ranges of 2-3 m in alarming proportions is likely to affect the recruitment and fishery. In this connection it is worth mentioning that sea ranching and tagging experiments carried out by using laboratory grown seed of ***P. semisulcatus*** have proved that shrimp production at Palk Bay area can be substantially increased by ranching seed of ***P. semisulcatus.***

Studies on molluscan resources have shown that fishing intensity of cephalopods such as ***Sepioteuthis*** spp. and ***Sepia*** spp. could be increased much more than the present level.

The local ground for sacred chank ***Xancus pyrum*** is found to be the best in India.

Data on commercial exploitation of seaweeds at 12 centres along the region indicated a declining trend in their production. New ground along the intertidal areas was located. The study has shown increased exploitation of the coastal resources over the years.

The investigations carried out on the fishery oceanographical and ecological parameters have given an insight into the influence of these factors on the seasonal and annual fluctuations in fish production and helped to estimate the potential fishery resources of the region.

Mariculture

A viable technology for induced maturation and artificial insemination in the tiger prawn, Indian white prawn and green tiger prawn has been perfected.

A protocol was developed for larval rearing of the crab ***Portunus pelagicus.*** F-1 generation of ***P. pelagicus*** was maintained upto F4 generation. Rematuration for mud crab was perfected to obtain repetitive spawning.

There farming of green shrimp, ***P. semisulcatus*** in the experimental culture ponds with hatchery-produced seeds revealed encouraging results to adopt this species for commercial culture.

Attempt made on the development of captive broodstock of ***P. monodon*** has given encouraging results and revealed the potentiality of captive broodstock development.

Several species of commercially important crustaceans were bred under captivity and their eggs and larvae were reared successfully. Hatchery technology was developed and standardised for ***P. indicus, P. semisulcatus*** and ***P. mondon.***

A commercial scale marine pearl oyster farm of 1000 sq.m was established and maintained at Gulf of Mannar. Packages of practices for cultured pearl production was developed and standardised.A total of 9000 pearls of different grades have so far been produced having a total value of Rs.7.0 lakhs. About Rs.1.75 lakhs have so far been realized through sale of pearls.

A pearl oyster hatchery with a production capacity of 2.5 million spat/annum was established and made operational.

A breakthrough was achieved in the spawning of abalone through thermal and chemical stimulation. The larvae resulted from the spawning was reared upto adults under controlled condition.

In the endeavour to develop technologies for controlled breeding and seed production in mullets and rabbit fishes, initial success has been achieved.

The induced maturation and breeding of seabass and groupers are being succeeded.

The pen culture of finfishes in the coastal lagoon showed encouraging results indicating the feasibility of developing the unproductive area to a productive one.

A simple low cost technology for culturing the agar and algin yielding seaweeds on long line coir ropes and coir nets in the near shore waters has been developed. Techniques for the mass production of live feed organisms such as rotifer, moina and brine shrimp to feed different larval stages of crustaceans and finfishes were developed and perfected.

Techniques for the mass culture of mirco algae ***Isochrysis galbana*** and ***Chlorella salina*** to feed the pearl oyster larvae and spat have been perfected.

Techniques for the preservation of dormant cysts of rotifer and artemia in dried condition were developed.

Cryopreservation of ***P. semisulcatus*** nauplii using DMSO-Glycerol was achieved with 40-50% survival at a low temperature of -10°C.

A breakthrough was achieved in the spawning, larval rearing and nursery rearing of the Clown fish, ***Amphiprion sebae*** under controlled condition.

Present Status of Mariculture in India

V.N. Pillai
Central Marine Fisheries Research Institute,
Cochin - 14.

Aquaculture, the farming of aquatic animals and plants has been the world's fastest food production system for the past decade with an average compound growth rate of 9.6% per year since 1984. On the basis of the rapid growth of the aquaculture sector and recent stagnation of landings from capture fisheries, aquaculture is seen by many as a potental source of hope to meet the current and future needs of a growing population in search of food. The marine ecosystem with its rich resource of fauna and flora has sustained both capture fisheries and mariculture activities. India ranks second in aquaculture production next to China. However 90% of the production is from freshwater ecosystem with very little contribution from marine sector. Though there is increased demand for seafood both in the domestic and export market the present marine fisheries scenario is characterised by declining yields from inshore waters and increased conflict between different resource users. However, the vast coastal zone indicates the prospects for augmenting the production through large scale seafarming.

The marine ecosystem of the Indian subcontinent is the niche of several marine resources of which the major resources on which the mariculture industry is built are the shrimps, lobsters, crabs, mussels, oystes, finfishes, seaweeds and pearl oysters. Due to the developmental activities of various governmental organisations vast areas in several maritime states were developed. However, out of the potential 11.9 lakh ha available for farming activities only 12.4% is currently utilised. One significan .ge witnessed by the Indian mariculture industry in the past few years is diversification of aquaculture activities wherein several other marine resources like the bivalves, ornamental fishes and other finfishes have also become significant candidate species for aquaculture.

Crustacean culture

One of the principal and highly valued aquaculture resource is the marine shrimp. In 1998 - 99 the production of farmed shrimp in India was estimated as 82,634 tonnes from 1.35 lakh ha. of which 86% of the production was from the farms along the East coast. Among the maritime states, Andhra Pradesh was the leading producer contributing 54.3% of the total production, followed by West Bengal and Kerala. While 81.7% and 92.4% of the shrimp production in West Bengal and Kerala was from the traditional farms, the production from such farms in Andhra Pradesh was negiligible. The dominant species was ***P. monodon*** followed by ***P.indicus***. However the scope for farming ***P. semisulcatus*** and non-penaeid species like ***Metapenaeus dobsoni, M. monocerus*** and ***M. brevicornis*** is also bright through rotation of crops.

Along with the increased production of farmed shrimp, the nation witnessed growth of aquaculture related industries like shrimp feed production units, hatcheries and processing plants. It has been estimated that to meet the growing requirements of this industry, about 70 shrimp hatcheries with a total capacity of 39,000

million seed and 30 shrimp feed mills (capacity 60.000 ton) were established along the south west and south east region of the country.

Lobsters are one of the highly priced seafoods whose trade increased in volume and value within the last decade. In India, lobsters like ***Panuilirus homarus, P.ornatus*** and ***P. polyphagus*** are farmed in the coastal ecosystem. However due to the extremely long duration of larval development and due to the cannibalistic behaviour of this group, a viable hatchery technology has not been developed. Instead, juvenile lobsters are collected from coatal waters and grown to marketable size. It has been observed that juvenile lobsters (40gm) can attain 100 to 125 gm when fed with trash fish, worms, crabs, echinoderms etc. The yield from a 70 sq.m. pond with a stocking density of 10-15nos/sq.m was 300 kg resulting in a net profit of Rs.50,000 for three crops a year. Supported by the encouraging results obtained in lobster fattening 'and the global demand for live and frozen lobsters, it can be predicted that scope for developing lobster farming in India is bright.

World trade for crabs witnessed a phenomenonal increase during the last two decades. Concurrent with the development of global market, crab culture/ crab fattening becomes popular in South East Asian countries India has several species of crabs suitable for farming viz., ***Scylla serrata, S. tranquebarica*** and ***Portunus pelagicus***. The present farming technique involves collection of juveniles (seed crabs) from wild, stocking in cages/tanks or earthen ponds followed by feeding with trashfish, clam, etc. for a period of 8 to 11 months. At present crab fattening is done in mangrove and coastal areas by small-scale farmers. The demand for live crab in the world market predicts a profitable investment opportunity.

Bivalve Mariculture

Characters like high tolerance to environmental variation and rapid growth of edible bivalves and the relatively simple farming methods have encouraged farmers to opt for commercial farming of oysters and mussels. Mussels which rank first in world aquaculture are grown on ropes suspended from rafts, longlines or racks. In India, two species of mussels, ***Perna viridis*** and ***P. indica*** have shown good culture potential. During the last five years, more than 2000 t of mussels were produced through mariculture activities along the southeast and southwest coast. Similarly oyster culture demonstration with the candidate species ***Crassostrea madrasensis*** has indicated high returns in 5 to 6 months. Moreover the technology for seed production of bivalves has been perfected and it is possible to meet the demand of a bivalve culture industry if required.

India successfully produced the first cultured pearl from ***Pinctada fucata*** in 1973. Since then due to relentless effort of the research team at the Central Marine Fisheries Research Institute a complete technology for pearl culture and hatchery production of spat were developed. India also won international recognition when a training programme funded by FAO/NACA/UNDP was held at Tuticorin RC of CMFRI for 26 delegates from 10 Southeast Asian countries. The Tamil Nadu Government and Southern Petrochemical Industrial Corporation Ltd., (SPIC) made pioneering attempts for commercial production of pearls in the past two decades. In the recent years, several industrial houses in the southeastern states have initiated projects on pearl farming with scientific support from CMFRI. According to industry sources, demand for pearls is on the rise and pearls with good lusture and colour can easily access the world market. This indicates that in the subsequent years pearl culture can emerge as a viable and sustainable form of economic activity which will further be catalysed by use of biotechnological approaches.

Finfish mariculture

It has been estimated that one in four food fish consumed by humans now is supplied by aquaculture. Finfish culture in the freshwater and brackish water systems is widely popular contributing to 98.8% and 33% of the global production from these two aquaculture niches, while in the marine environment their contribution is only 8.3%. Marine fishes are mostly carnivorous and are reared in cages or other intensive culture systems like raceways. In the temperate countries mariculture of finfishes is well established. In most Asian countries cage culture of groupers such as ***Epinephelus tauvina*** and ***E. malabaricus*** using seed collected from wild has given yields of 20 tons/ha/yr. Similar grouper species are abundant in Kerala and Tamil Nadu coasts of India. Other potential species available for aquaculture are seabass ***(Lates calcarifer)***, milkfish ***(Chanos chanos)*** and mullets ***(Mugil cephalus).*** Yet another group under finfishes are ornamental fishes, many of which can be reared in aquarium tanks, ponds and cages. The coral reefs around Andaman and Nicobar and Lakshadweep Islands are blessed with wide variety of ornamental fishes. This indicates scope for developing our resources which are at present not fully utilised. In India, marine finfish culture is still in the experimental stage and preliminary success has been achieved in culture and breeding of oronamental fishes.

Seaweed culture

Many species of agarophytes and alginophytes occur along the Indian coast and their farming methods have been developed. The vegetative propagation of ***Gracilaria edulis, G. corticata, Gelidiella acerosa*** and ***Sargassum spp*** has been demonstrated. High yields, (5kg/m^2) in the case of ***G. edulis*** and 3 kg for ***G. acerosa*** has been obtained in 80 days. It has been shown that bulk of the farmed aquatic plant production, 6.81 mmt in 1995 or 87.1% of total global aquatic plant landings including brown red and green seaweeds was produced as a food source for direct human consumption. In India studies have indicated the possibility of large scale seaweed culture along the southeast coast of India.

Bioactive substances from marine resources

Marine fauna and flora are rich in bioactive substances that have immense pharmaceutical value presently twenty two species of gorgonids are being exported from India for the production of bioactive compunds. The CMFRI has studied the biotoxicity of more than 118 species of benthic algae, sponges, gorgonids, alcyonarians, corals, molluscs, echinoderms and flagellates from the Indian seas around India. Current research thrust is to screen the occurence of organic chemicals and biochemicals such as cardiotonic polypeptides from sponges, anticancer agents and prostagladins from gorgonians and soft corals. The future holds great promise for the develpment of new drugs from these marine organisms and it is hoped that the first step that we have taken will be the backbone for further development.

Stock enhancement programmes through sea ranching.

The developments made in hatchery seed production techniques has made large scale seed production possible for different species of crustaceans and bivalves. This has helped the nation to augment the stocks through searanchin. The searanching programmes of Japan, China and US has helped them to develop the fishery of shrimps and finfishes. The ranching of pearl oyster seed / larvae and the post larvea of banana prawn in the Gulf of Mannar and Palk Bay has helped in the revival of barren pearl oyster beds and augmented the yield of ***Peneaus semisulcatus.*** Such stock enhancement programmes which help in the revival of capture fisheries are planned for sea cucumbers, clams and other lobsters.

Conclusion

While reviewing the recent developments in the Indian mariculture industry it is evident that the pace of growth of shrimp farming was suddenly hampered by disease incidences. Though the precise reason for this has not been established, diagnostic studies conducted in India and abroad have shown that there is a linkage between environment and health of the organism. Despite the crop failures, shrimp farming continues to contribute substantially to marine food production. The development of mussel and oyster farming as a rural / community programme in Kerala is a land mark in Indian mariculture. For rural upliftment similar programmes can be charted out for other maritime states also. The progress made in culture of marine ornamental fishes and pearl farming has indicated that an industry which can provide employment to several coastal fishers can be developed through proper planning and cooperation between planners, reseachers and industrialists. While charting out the developemental programmes it is imperative that awarness among the resource users about the significance of a clean and healthy environment for sustainable marticulture should be created.

Diatoms to whales: My research and field experiences in the Gulf of Mannar and Palk Bay in the vicinity of Mandapam, along the south east coast of India

P.S.B. R. JAMES
Kamaraj Road,
Bangalore - 42.

I am exhilarated and immensely thrilled to narrate my research and field experiences in the Gulf of Mannar and Palk Bay in the 1960s, 1970s and 1980s for publication in the souvenir on the occasion of the Golden Jubilee Celebrations of the Recreation Club, CMFRI, Mandapam Camp which I also served as Secretary and President for some years in the past.

The momentous and great day in my career was when I approached Mandapam Camp railway station on the 8th December 1958. I saw first the coast of Palk Bay running parallel and along side of the railway line and soon the vast Pillaimadam lagoon. The scenery was quite enchanting. After alighting from the train and as I travelled in a vehicle towards the Institute and ascended the sand hillock, the great Gulf of Mannar and the chain of islands far beyond the shore came in sight. As I entered the campus, the atmosphere looked so serene and calm with shady trees on both sides of the inner road. The beautiful and enchanting marine environment surrounding the place made instant and deep impression on my mind that it could be an ideal place for marine biological research and soon I realised it nothing short of a marine biological paradise.

Early parambulations in and around the place and on the adjacent islands and the varied nature of the coast and beaches convinced me that there could be enormous scope for a naturalist's observations. Indeed, great naturalists like James Hornell and Gravely and several others in later years laid the foundations for marine research at this remarkable place, though isolated from civilisation but strategically surrounded by the sea on three sides.

A novice for marine science and a very fresh post graduate from the Banaras Hindu University, I soon developed keen interest in the subject and set to work for the doctoral work on Fishery Biology. During the course of collection of field data, I availed the ample opportunities offered by nature to make several other significant observations on marine plants and animals right from diatoms to whales. I do not hesitate to attribute this vast scope for research to the very environs of Mandapam Camp, perhaps not found at any other place in the country. The unique location of the place at the very lands end on the south eastern corner of the country, bounded by the Palk Bay in the north, Gulf of Mannar in the south, their confluence at the Pamban channel and a remerger on the east

of Rameswaram island over the Adams bridge makes it an ideal place for marine biological and oceanographic research. Added to this, the reversal of the winds associated with the north east and south west monsoons entirely change the oceanographic phenomena in the area which characterise and govern the abundance and distribution of living resources of the Bay of Bengal in this region. Concommittant with this, the fishing seasons alternate in the Palk Bay (Apr-Oct) and the Gulf of Mannar (Nov-Mar). The proof of this lies in the seasonal roughness, ferocity and turbulence of the water masses in Palk Bay and Gulf of Mannar which largely dictate the fishing activities. These phenomena often puzzled the biologists and oceanographers due to non-availability of scientific data continuously over an year. However, efforts have been made to provide information to bridge the gaps, though not entirely satisfactory. The shores and sea bottom off the coasts of Palk Bay and Gulf of Mannar are quite diverse in nature - sandy, rocky, muddy with adjoining lagoons and mudflats harbouring an immense variety of animals and plants. The noteworthy feature is the north east monsoon winds drive ashore very large medusae to the Palk Bay coast which harbour a number of commensals. The intertidal region, especially of Palk Bay, gets exposed for good distance from the shore (upto about 0.5 km even) at zero - and low tides offering scope for collection and observations on a wide variety of marine organisms.

As it where, the ocean at Mandapam beckons one to appreciate the richness of fauna and flora and derive the pleasure of observing and studying them in their own habitats. My initiation for the first time into marine research came from the late Dr. S. Jones, Former Director of CMFRI and my mentor who encouraged and guided me at all times to pursue this field of study. I owe a large measure of gratitude to him for all the benovalene bestowed on me. My very first finding was to record the occurrence of an additional species of ribbonfish, ***Eupleurogrammus intermedius*** which was till then confused in its identity and merged with the closely related ***E. muticus.*** Research work on this family of fishes including the biology and fishery enabled me to obtain the Ph.D. degree of the Banaras Hindu University. My camping for about a week at Idinthakarai (Gulf of Mannar coast) gave me a wonderful opportunity to witness the rise and fall of the abundant catches of the most dominant species of ribbon fish ***Trichiurus lepturus*** during its southward migration in large schools in the post-spawning period. The bag net catches landed by catamarans slowly increased, reached a peak in a few days and declined gradually as the schools moved away south. A similar phenomenon was observed in a sequence at Cape Comorin and Vizhingam (south west coast) as the schools evidently went round the sub-continent in the following days. However, I did miss an opportunity of describing a new species of ribbon-fish from the Gulf of Mannar due to several reasons, although I had a lot of material with me. Based on similar material, a new species, ***Trichiurus gangeticus*** was described later by another scientist from the Hooghly estuary. A memoir on the ribbon-fishes of India by me is one of its kind today based on comprehensive observations on this group on an all-India basis including systematics, anatomy, biology and fishery.

Another land-mark contribution is my research on the fishes of the family Leiognathidae from the Palk Bay and Gulf of Mannar which includes the description of two new species of silverbellies ***Leiognathus jonesi*** and ***L. striatus*** under joint authorship; reporting on the occurrence of two additional species of the same family, ***L. leuciscus*** and ***L. smithursti*** besides extensive observations on the biology and fishery of a number of species of the same family and a comprehensive account of the osteology of all species of the family which enabled me to draw the genealogical and evolutionary trends in the closely related three genera of ***Leiognathus***, ***Gazza*** and ***Secutor.*** Except ***L.equulus*** and ***L. fasciatus*** which attain larger sizes (usually caught in gill nets in the Palk Bay),

most of these fishes have a short lifespan. Hence advice was given to the industry to fish for the resource irrespective of the size and season, for if left unfished, they are no more available. Either natural mortality would take place or they are preyed upon by predatory fishes.

My field work in Palk Bay and Gulf of Mannar for about 15 years in two spells of my stay at Mandapam during 1958-69 and 1978-82 provided me ample opportunities to make short-term observations on diverse species of marine fishes which, I am sure, no other location can provide. As a novice to marine fisheries, as early as in 1961, I saw something white reflecting sunlight on the beach near Pudumadam along the Gulf of Mannar coast as I was travelling on a mechanised boat. As the sight was unusual, I wanted to land at the place. To my astonishment, I found hundreds of the cow nose ray, ***Rhinoptera javanica*** heaped on the beach, the white ventral sides reflecting light. It was revealed that shoals of the species were captured in shore seines little earlier. Since such occasions are rather rare, I made several observations on the material. They appeared to be on their breeding migration as many females carried young ones. The ray is known to be predatory on pearl beds. The trawlnet catches landed from Palk Bay used to contain large quantities of butterfly rays of the genus ***Gymnura.*** By then, I was aware that practically no information was available on these really 'butterfly' looking rays. Since I was regularly visiting the fish landing places along both the coasts, I was able to collect biological and fishery data on ***G. poecilura*** and published the same. These rays seem to be more abundant in Palk Bay than in Gulf of Mannar. The other elasmobranchs which attracted my attention are the large hammer-heads (***Sphyrna*** spp.), sawfishes (***Pristis*** spp.), the tiger shark (***Galeocerdo tigrina***) and the devil rays (***Manta manta***) landed occasionally in gillnets operated in Gulf of Mannar. They are not come across in the catches from the Palk Bay. These fishes are of great biological and fishery importance due to the massive sizes attained by them (20-25 ft in the case of the sharks and one to two metres across the disc in the case of the ray), their highly predaceous and carnivorous nature, prey-predator interaction, food chain relationship, lack of information on the breeding and population density, damage to fishing nets, difficulties in landing them and their economic value. Due to paucity of material and unpredictability of capture and landing, I was unable to make any detailed study but derived utmost satisfaction of seeing some of the massive creatures from the Gulf of Mannar. Any one who had seen the number, structure and mobility of teeth and their arrangement in as many as seven rows in the upper and lower jaws of the tiger shark of the size I mentioned above, would not but believe the narrations or stories that these powerful and mighty fishes can chop off easily parts of human bodies if they accidentally come across any. Because of the ferocity of the fish exhibited vividly in its jaws and teeth and rarity of the fish in its coastal waters, I ventured to get the jaws of a large tiger shark and kept in the museum of CMFRI so that others could also see and appreciate.

My study and observations on a wide variety of other fishes from the Palk Bay and Gulf of Mannar brought out several biological, behavioral and fishery related data and information. The instances are important because either the fishes are less known, queer, large or peculiar in behaviour. As I was visiting Rameswaram for fishery survey work, sometimes at night also, I was attracted by the easy capture of large quantities of ***Anchoviella*** spp (white-bait) off the coast in Palk Bay with torches called 'soonthu'. This indigenous method of attracting fish by light produced by burning dried palm leaves was found by me to be very economical in view of the high cost of fish and demand as dry fish. The same Rameswaram coast was a sight to see when heavy landings of large ***Chorinemus lysan*** (75-100 cm) took place. Because they are so large, the heads, guts and gonads are removed and thrown on the beach. Dogs on the beach

used to have a feast of this material and become very fat! Taking advantage of the situation, I made a short study of the size variations, food and breeding habits of the fish, practically incurring no expenditure. Seaweeds, especially ***Sargassum*** spp are abundant in the shallow waters of Palk Bay at Mandapam. They harbour a variety of organisms amongst the fronds. Washing freshly collected ***Sargassum*** easily yields them. The numerous small pipefishes (family ***Syngnathidae***) attracted my attention on several occasions. Sorting and identifying these queer-looking fishes revealed an undescribed genus and species of pipe fish from the seas around India. It was identified and described by me as ***Micrognathus brevirostris.*** The Indian sand whiting ***(Sillago sihama)*** used to be caught in large quantities in shore seines along Palk Bay, especially in the vicinity of Mandapam in the 1960s. I found the situation entirely changed in the 1980s when the catches rapidly declined, perhaps due to indiscriminate fishing of immature fish (mostly 8 to 12 cm). Short stretches of the shallow waters at certain places along the coast were found to serve as nursery grounds for early juveniles. Large individuals of ***Plectorhynchus*** spp. were often found in groups in clear waters in Palk Bay and under the Pamban bridge. I found the fish very foolish and do not move even when a diver approaches and they could be easily caught by piercing with simple sharp iron rods. The Kundugal Point (Gulf of Mannar near Pamban) and many other localities in the vicinity were found to be important collection centres for the seed of milkfish (***Chanos chanos***) and mullets (***Mugil*** spp) but it is still a paradox while the seed of these fishes is so abundant in the area, the adult and mature/spawning fish are very rare. Seacucumbers were found abundant in the same mudflat areas. The schools of mullets are not uncommon in Palk Bay but they have been found to be composed of immature fish, often getting disturbed and jump into the boat when schools are intentionally intercepted by the boat. Fishermen attribute appearance of mature fish at certain seasons to be in the coastal waters of Palk Bay associated with particular wind and current direction. The team under my leadership was able to breed ***Mugil parsia*** and initial experiments indicated that third to fifth day is very critical for the survival of the larvae when appropriate live feed seemed essential. A series of monoculture and polyculture experiments were conducted at Mandapam with milkfish, mullets and prawns. ***Tilapia*** had been found to be nuisance in salt water fish culture ponds at Mandapam.

Other interesting observations I made in the Palk Bay include the occurrence of large schools of the catfish ***Tachysurus dussumieri*** (about 75 cm in length) which have been observed to churn up the muddy bottom, evidently in search of food. The schools can be detected due to the appearance of large brown circular patches of turbid water on the surface. During my cruises on the Indo-Norwegian Project (INP) boats in the Palk Bay I found enormous schools upto 15 ton in a haul of the catfish captured in purse-seines. ***T. coelatus*** is the other dominant species in the Palk Bay. Both species have been found to breed profusely in the area as they were often found with eggs in the mouth. I vividly remember a boy on the boat was very badly injured on his back when a worker accidentally threw a large fish to another side of the deck when it straight went and pierced and stuck on the back of the boy with its strong and powerful dorsal spine. Without using force, the spine could not be pulled out. So strong are the spines of catfish! The trawl net catches from Palk Bay used to land large quantities of sea snakes of various species but no study had been attempted so far. A golden opportunity for some one interested in herpatology. Fishermen used to very carefully avoid them. The eels were also quite frequent in the catches and I happened to spot out a very large moray eel, ***Thrysoidea macrura*** (over 10 ft long) which is the second largest on record in the world and kept stuffed in CMFRI museum at Mandapam Camp.

Systematic trawling experiments were conducted in the Palk Bay and Gulf of Mannar by the INP boats in the 1960s and 1970s and I could make use of this opportunity to collect material of silver-bellies for my research work on the group and published a joint authorship paper on trawl fishing in Palk Bay and the Gulf of Mannar. These and other observation made by me indicated that larger fish and abundant catches of the ribbon fish, ***T. lepturus*** can be harvested by trawling in deeper waters beyond 50m depth and in coastal water (less than 50 m depth) in the post- spawning period when they school and get caught in bag nets and shore seines.

Preliminary experiments were conducted on cage culture in Palk Bay to determine the suitability of locally available material for fabricating the cages and use of species like ***Epinephelus tauvina.*** Useful information has been generated. Attempts were also made to maintain large mullets and milkfish in hapas in coastal waters of Palk Bay for breeding purposes but rapid development of filamentous algae inside the hapas restricted movement of fish in the hapas by entangling them and causing mortality. Large pens erected in Bay also did not prove useful to maintain the fish as silt soon accumulated inside the pen like a mound reducing the depth of water and creating difficulty for the fish to swim. A detailed study of the hydrobiology of Pillaimadam lagoon was conducted with a view to convert a large part of the lagoon into a salt water fish farm. This was suggested because pen culture experiments conducted by other scientists in the open lagoon with milkfish and mullets hardly yielded 200-250 kg per ha/5-6 m. The very high saline conditions, retarded growth and production indicated the need for supplementary feeding for obtaining better growth and production and also diversifcation of species for culture.

My experience in research with algae in the Palk Bay and Gulf of Mannar though very limited, was very exciting and rewarding. Quite accidentally, I stumbled on the blue-green alga, ***Trichodesmium thiebauti*** to report it for the first time in the Gulf of Mannar, though several earlier authors reported only ***T. erythraeum*** from the region. I sent the material to Prof. Desikachary of the Madras University who confirmed my identification . I had observed ***Trichodesmium*** blooms in Gulf of Mannar now and then but on one occasion

go into detail. The aquarium suddenly started dying. The water in the tanks turned yellowish (though running water is circulated 24 hours). Fowl smell emanated inside the building. Seawater in the sump and overhead tank, when checked, emanated the same foul smell. Some lumps of floating material were observed at both places. The sea water from Gulf of Mannar from where water into the aquarium was pumped, was collected in a beaker and observed. It contained a high concentration of 'floating bundles' visible to naked eye. The winds along the beach had bad odour. Coastal waters were discoloured yellowish -brown. On, examination under the microscope, the 'bundles' could be identified as ***T. thiebauti.*** The mortality of the fish in the aquarium was evidently due to the large scale death and decay of the alga in the water and consequent leaching of toxins and asphyxiation of fish. Some species of leiognathids are known to be symbiotic with luminiscent bacteria. But I found ***Leiognathus dussumieri*** collected from fish landed by bottom gillnets from the Gulf of Mannar at Kilakarai harbouring an algae on its dorsal, pectoral and caudal fins and sometimes parts of the body also.

Seagrass and seaweed beds are extensively found in the coastal waters the Palk Bay and Gulf of Mannar. However, ***Sargassum*** appeared to be more abundant in Palk Bay than in Gulf of Mannar and vice-versa for seagrass. During the course of my observations as leader of the lab to land programme on seaweeds, I found luxuriant growth of seaweeds could be obtained in the Gulf of Mannar compared to the Palk Bay, possibly due to the nature of sea bottom, clarity of water, wind, current and wave conditions. Large quantities of seaweeds are washed ashore along the Gulf of Mannar coast

during the south west monsoon period when rough seas are prevalent. However, the correct hydrological and ecological factors responsible for good crops and bad crops of cultured seaweeds have not yet been pin-pointed. In the meanwhile, regulated cropping of natural beds based on scientific studies have been advocated. It was felt, unless seaweed production by culture is directly linked to processing and product development, it may not be an economic venture.

Camping once for 24 hours at the Manauli island provided an opportunity to me to observe a number of marine biological phenomena and collection of material for research. The shallow, very clear waters along the shore at low tide revealed the abundance of the large greenish looking sea anemone ***Stoichactis*** sp. with which the anemone fish is associated. Apart from observing the fish going in and out of the stomodeum of the coelenterate, many intricacies of the association could be studied. It was a herculian task to unearth the sea anemone from its habitat even for 3 or 4 persons since the soil around the body has to be removed upto its base to dislodge the anemone whose base was found to be located at about 3 ft underground. I had the pleasure of interlocking my fingers under its base lying prostrate and 2 or 3 people lifting me up with force to uproot the anemone. The anemones with fish inside were collected and transported to the aquarium for further observations. What a wonderful experience indeed. The 'Kallan-Katti valai' (a sort of stake net) operated at the edges of Manauli and other adjacent islands at high tide is a unique and no-cost operation capturing a wide variety of fish and prawns as the tide recedes. Mullets and other species could be collected live for research purposes. I had the oppurtunity to make some observations on the eggs of the only marine insect, ***Halobates*** sp. found attached to a ***Sepia*** shell. The colourful black and red winged butter flies of the genus ***Papilio*** regularly travel back and forth across the Gulf of Mannar from the mainland to adjacent islands during certain periods.

The richest and most valuable research experience I had in the Palk Bay and Gulf of Mannar is with the largest denizens from the ocean (the whales) and the meekest, the dugong or the sea cow. I must say, to my good fortune (because many would not have had), I had the personal and most exciting experience of working with several stranded whales along these coasts. The enormity of the task was as large the giants, seven or eight of which ranged between 45 to 80 ft in length. Most were baleen whales stranded only along Palk Bay coast while the sperm whales (I saw one full and another head skeleton only) appear to be stranded only along the Gulf of Mannar coast. While the reasons for stranding are yet unknown even in other locations in the world, since there was no visible injuries, signs of shooting or senility (based on sizes), the possible cause could have been the failure of the sensory system to distinguish deep sea and the open shallow waters, Which they encountered as also opined by other scientists elesewhere in similar cases. Having once entered the shallow waters, it is unimaginable the heavy bodies can be sustained by buoyancy to lift themselves and turn around. As Officer-in-Charge of the Museum and Aquarium, I was given the charge of retrieving the complete skeleton of a large baleen whale (about 80 ft) stranded at Karangadu along the Palk Bay coast. A number of us, scientific and technical staff and workers, camped in tents at the site and transported parts of skeleton by sea in boats and by road. The whole area and the coastal waters in which the carcass was decomposing for about a week was stinking, with fowl winds blowing all over the place. Having worked with the whale for a week to dismantle the skeleton, our bodies and clothes also absorbed the stink. It took a few days to get rid of the fowl odour. The coastal waters became red and oily with leaching of blood and oil from the body of the decompossing whale. Although the bones of the whale are said to be porous and buoyant helping the whale to sustain its enormous weight in water, it was amazing to see that six persons could not lift one half of the mandible.

We successfully transported every bit of the skeleton to the Institute, buried some parts on the beach, some were tied and kept in coastal waters of Gulf of Mannar and others on roof tops for complete removal of flesh and oil. Unfortunately, the 1964 cyclone devastated every thing in the area and most of the skeletal parts kept at sea were washed away and lost. Due to this unforeseen catastrophe, a very valuable exhibit has been lost and all efforts to secure the skeleton had been in vain. Years later, during my second sojourn at Mandapam Camp (1978-82), I had the opportunity to work with a complete young sperm whale ***(Physeter macrocephalus)*** and the head skeleton of a large sperm whale stranded at Krusadai and Manauli islands respectively. The detailed osteology of these were studied by me and a colleague, the skeletons deposited in the museum and a paper published which reviewed all strandings of whales along the Indian coast from 1748 to 1982. The study also enables one to estimate the total length of the sperm whale if the condylo-basal length of the skull is known.

During my stay at Mandapam Camp I found the capture of dugons was quite common, especially at places like Vedalai and Kilakarai (Gulf of Mannar) and Tondi (Palk Bay), though more reports came from Gulf of Mannar. I had the opportunity to study the animal both at field and in the laboratory along with other colleagues. A few live dugongs were reared in the aquarium and others dissected for anatomical details. The extraordinary long intestine contained mostly seagrass in fresh and semi-digested condition and also a variety of parasites. I made a personal comparative study of the skeletons of an adult and a baby dugong which were deposited in the museum and a paper was published. Since the meat is a much sought after delicacy in the coastal areas, the animal appeared to have been intensively hunted and the population decimated rapidly over the years. In some cases, I observed the tail spines of rays embedded in the flesh of the dugong, indicating some sort of struggle in the habitat between the dugong and the rays whose tail spines can be pulled off with some force. The animal is now protected under the Indian Wild Life Act but precious little had been done by the Government to protect the animal and its environment, though the Institute made repeated pleas for the same. *In-situ* and *ex-situ* conservation methods have to be urgently applied. I had made a personal plea for formulating and implementing the "Project dugong" on similar lines as 'Project tiger' but in vain. Trawling operations in the Palk Bay and Gulf of Mannar can cause great damage to the seagrass beds in the area which largely determine the distribution pattern and occurrence and well being of the animal. Observations on live dugongs in the aquarium indicated that they can be bred under those conditions given larger and deeper tanks are made, fresh sea water pumped in and changed every day and adequate quantity of food provided. Therefore, the possibilities of captive breeding of dugong to replenish the population are quite high, at mandapam Camp as done in other countries.

The foregoing account amply indicates the rich and varied marine resources of the Palk Bay and Gulf of Mannar providing immense scope and opportunities for excellent research. I feel highly gratified and satisfied that I made the best use of of my stay at Mandapam to understand and study some of the fishery resources of high economic importance and at the same time become familiar with the unique marine biological, fishery oceanographic and environmental conditions in the area. I am of the conviction that the Palk Bay and Gulf of Mannar would continue to enjoy the pride of place as the ideal environs for marine biological investigation and provide the challenges for further research, rational exploitation, conservation and management of marine resources.

In view of my intense field work and research experience for about 15 years in the Palk Bay and the Gulf of Mannar, I feel we must derive the maximum benefit of the living

resources and ideal environment offered by these two wonderful segments of the Bay of Bengal. Of particular interest would be to develop a large oceanarium at the Regional Centre of CMFRI for display and research on the highly diversified fauna and flora. Through such a facility, captive breeding of the dugong could become a reality and the endangered animal can be protected from getting extinct. A number of commercially important marine finfishes can be bred including the eel ***Anguilla bicolor*** and seed supplied for seafarming and sea ranching. The oceanarium would aid in the study of behaviour and physiology of marine animals. A sound foundation can be laid for marine ornamental fish breeding and culture for export. Besides its scientific and educative value, the oceanarium would help create public awareness and concern for marine animals, especially the endangered species. I foresee, if such developments can be given effect to quickly, a National Marine Biodiversity Research Centre and National Seafarming Institute can blossom at the Regional Centre of CMFRI, Mandapam Camp.

I am singularly proud that I began my research career here and ended up to head the same Institute, which I would ever cherish in my life. But for the research work done in the Palk Bay and the Gulf of Mannar, I would not have been able to get the D.Sc. degree of Banaras Hindu University. Three cheers to Palk Bay and Gulf of Mannar!!!

The need for a systems approach to the development of the coastal agroecosystems in the Gulf of Mannar area

M.Devaraj
Plot No.5, First Street, Venkatakrishna Nagar, Arumbakkam, Chennai-600 106.

Introduction

The Gulf of Mannar is bordered by Ramanathapuram, Thoothukudi, Thirunelveli and Kanyakumari districts. Most of this coast is dry, and experiences only limited rainfall during the northeast monsoon. The mainstay of the population is comprised by marine fisherfolks, marginal farmers and landless labourers. Marine fish production has already reached its peak, and there is little scope for the expansion of capture fisheries. No large - scale agricultural farming is possible because of the limited irrigation potential. Agricultural operations essentially comprise seasonal millet and paddy cultivation and sheep rearing. The coastal terrain is saline and / or alkaline, and infested with xerophytic small trees belonging mainly to *Acacia* and *Prosopis juliflora.*

Against this background, a systems approach is suggested here to tap the existing natural resources (both marine and land) with the help of modern farming technologies to ameliorate the livelihood of the coastal communities of this region.

Integrated coastal mari-culture and seafarming

A large number of coastal shrimp farms and hatcheries came into existence along the Gulf of Mannar coast since 1990. Most of these farms were of smaller size ranging from 2 to 5 ha area. The larger farms invariably and operated a hatchery also. Significant among the larger complexes of farms hatcheries were SPIC, Minota Aqua, Victory, MIL and Gem group. All these larger farms and some of the smaller farms have closed their operations because of the combined effects of legal interventions, social opposition, whitespot disease problem and formation of acid sulphates in the farm ponds.

Service agancies belonging to the Central and State sectors could not do much to reverse the process and restore the farms to sustainable levels. As a result, the enormous capital invested in this sector is remaining idle. The substantial employment potential created by the sector could not accrue to the coastal poor. It has been realized that the only viable alternative to coastal shrimp monoculture is to introduce and popularize polyculture by integrating pearl oyster, seaweeds and seacucumber with shrimp in farm ponds with a bottom lining of silpaulin and sealing the inner surface of the pond dykes with biocrete (a mixture of cement, sand and powdered coconut husk pith).

While silpaulin and biocrete prevent acidification of pyrites in coastal soils, pearl oyster, seaweeds and seacucumber utilize effectively the wastes released by the shrimp stock in the ponds. The regime of feeding the shrimp stock and water quality management generally followed in shrimp monoculture should continue to be followed in this polyculture, with suitable modifications, appropriate to the integrated components.

In order to demonstrate this new package of practice to the defund and / or problem farms, the 5 ha research farm of the Mandapam Regional Centre of the Central Marine Fisheries Research Institute (MRC of CMFRI) at Mandapam Camp was developed into a model polyculture farm. This farm, which is now running very successfully, may take up onfarm trials throughout the Gulf of Mannar coast to popularize the polyculture technology on a mission-mode approach. The Department of Fisheries (Government of Tamilnadu) and the Marine Products Export Development Authority (MPEDA) should come forward to join the efforts of the CMFRI to take up this programme without any further delay. The industry is both ignorant and oblivious to the polyculture package developed by the CMFRI at Mandapam Camp. Invitations were sent to all the shrimp farm owners throughout the country for their participation in the National Symposium on 'Eco-friendly Mariculture Technology Packages - An Update' being held at the MRC at Mandapam Camp on the 25th and 26thApril, 2000, but the response has been so poor.

In a detailed study conducted by the CMFRI, Kochi, in September - October, 1998, it has been found that 45,537 of the 76,596 artisanal non-motorized boats, 34,925 of the 50,922 artisanal motorized boats and 28,144 of the 49,070 mechanized boats are surplus, and hence, are economically unproductive. A new system has been designed by this author for the conversion of the surplus boats into floating, mobile, motorized seafarms in phases. It is made by rigging four artisanal boats of the same size into two pairs and connecting the two pairs by a series of alternative wooden planks and metallic rods. The planks serve as bridges for the movement of men and materials, while the rods are meant for hanging ropes (rens) seeded with the selected candidate species (e.g.) pearl oyster, mussel and seaweed. The outer boats of each pair can be properly roofed for storing materials and for the crew to stay. Each unit is powered with two outboard engines of suitable horsepower depending on the size of the unit. Since the hanging rens serve as fish aggregating devices, fishing should be undertaken daily using low energy gears like traps, jigs and hooks & lines. A carrier boat has to be deployed for bringing supplies to the seafarm and taking the catches ashore. The MRC of CMFRI may construct this model seafarming-cum-fish aggregating-cum-seafishing platform and run it as one of its frontline activities and simultaneously undertake training of fisherfolks on this new venture.

Overfishing has resulted in the decline of many of the demersal fish stocks in the Indian seas, especially during the last one to one-and-a-half decade. Uncontrolled bottom trawling has caused considerable damage to the precious benthic habitats. In order to build new benthic habitats, which could facilitate colonisation by a large number of marine organisms, both flora and fauna, ranging from the algae to apex carnivores, a scheme of artificial reefs has been introduced by the Government of India since the Seventh Five Year Plan onwards. However, only 32 reefs in the extreme southwestern coast (Thiruvananthapuram and Kanyakumari districts) 2 reefs in the Gulf of Mannar (Thoothukudi district) and 2 reefs in the Chennai coast (Chengalpet district) have been installed so far, Gujarat, Maharashtra, Andhra Pradesh and Orissa states have initiated some steps in this regard, but no significant development has taken place so far.

The CMFRI has developed standard designs of artificial reef, and has helped the Government of Kerala over the last one decade in the creation, installation and operation of these reefs successfully as community reefs. Based on this experience, the MRC of CMFRI, Mandapam Camp, may create a standard artificial reef complex at an appropriate depth in the immediate vicinity of its research

facilities and undertake regular fishing jointly with the fisherfolks of the neighbouring villages in order to popularize this practice among them. The necessary funding may be obtained from the Ministry of Agriculture through the Department of Fisheries of the Government of Tamil Nadu. The floating, mobile seafarm described above can operate from above this artificial reef or independently of it any ground where optimum conditions prevail.

There are in all 13 regional research centers and 28 Field Centres under the CMFRI located along the Indian Coastline. The integrated coastal onshore polyculture and seafarming together with a system of artificial reef complexes proposed in this article to be developed by the MRC of CMFRI, for the Gulf of Mannar coastal agroecosystem can be replicated in the country's entire coastal ecosystem through the above institutional network and the various state fisheries departments in phases through the successive five year plans. Following the success of India's Fish Farmers' Development Agencies (FFDAs) in the freshwater aquaculture sector, it is important to create Sea Farmers' Development Agencies (SFDAs) for every coastal district in the country to bring about rapid development changes in the seafarming sector in the country, along the lines proposed in this article.

Intergrated inland farming system

In spite of a highly arid climate and low rainfall, the coastal districts of Gulf of Mannar offer ample opportunities for integrated inland farming of various agricultural, livestock and fish crops. In developing such systems, the local natural resources of plant, animal and fish species need to be taken into consideration. Irrigation is very crucial in the development of farming systems, and therefore, the initial focus should be on locations where proper irrigation could be source. Where there is fairly good groundwater potential, one of the best low-cost options would seem to be the farming of small ruminants (sheep and goat) by the small households and on a large-scale. The required fodder grass, fodder trees and fodder grains can be developed in farms, the extent of which will depend on the irrigation potential of the aquifer. These farms may be declared as community farms, where individual households will be given independent plots to raise the required fodder for their small household flocks to supplement natural grazing during day time. The irrigational infrastructure development is the responsibility of the Government, while the households are responsible for the proper maintenance of their fodder plots. Goat and Sheep Farmer Development Agencies (GSFDAs) under the Chairmanship of the District Collector can be thought of as an Institution for the promotion of this venture, which has immense potential for rural employment and income generation.

Many such low-cost options could be identified depending on local situations, opportunities and resources. In locations where the groundwater is brackish and alkaline, and cannot be used for agriculture or domestic purposes, salt and alkali tolerant fodder grass like paragrass ***(Brachiaria mutica)*** and fodder trees like ***Acacia nilotica*** could be grown with proper gypsum application, rather profusely, to sustain goat and sheet farms. In fact, if there exists good supply of such water from the subsurface aquifer, shrimp culture could be integrated very profitably in this system by storing the water in farm ponds before irrigating the fodder plots. The sprawling institutional campus of over 100 acres in the MRC of CMFRI, Mandapam Camp seems ideal enough to take up this model development with inputs from the District Collector and the Departments of Rural Development, Animal Husbandry, Fisheries, Agriculture and forest of the Central and State Governments.

Govenment institutions in India are generally tuned to specific tracts as per their defined mandates. Where necessary, these

institutions need to be re-oriented to take up community tasks, which function essentially on a systems approach. Development agencies can be the best institutional model at the District level where all specialist institutions (both development and research categories) can contribute to the emergence of farming systems in the coastal agroecosystems in thecountry.

The Sea Cow, *Dugong Dugon* Of India

R.S. Lal Mohan,
Conservation of Nature Trust,
43-C, Water Tank Road,
Nagercoil - 629 001.

The sea-cows or the dugongs are distributed in the Indo-Pacific region between longitudes 32°E and 170°W, latitudes 35° and 40°N. There are five population namely, East Australian, North Australian, Andaman-Malay Peninsula, Thailand and South China, South Indian and Sri Lanka, East African, Red Sea and Persian Gulf.

Dugong has a wide distribution in the tropical Indo - Pacific region. They are recorded from East Africa, Mafia Island, Kenya, Red Sea, Persian Gulf, Gulf of Mannar, Palk Bay, Sri Lanka, Andaman Island, Burmese Coast, Merqui Archepelago upto New Caledonia and Philippines Island. At present the dugongs are found in good numbers in the coast of Australia but becoming depleted in other places.

The body of the dugong is spindle-shaped and can be divided into head, trunk and tail. The head is small and characterised by the muzzle, a horse shoe shaped extension of the upper lip specialised to browse at the bottom of the sea. The surface of the muzzle has large number of bristles. In the male a pair of insicors are found. The eyes are small. Nostrils are a pair of cresent shaped openings located dorsally. Ear openings are small without ear lobes.

The dentition consists of incisors and molars, canines are not present. There are four pairs of incisors in the lower jaw in the young dugong but these are lost in the adult. When the teeth are shed, the sockets are filled with bony matter.

Dugongs usually attain a maximum length of about 3 meters.

Dugongs are well adapted for an aquatic life. The fore limbs are modified into flippers and the hind limps are absent. The pelvic girdle is absent and represented by two small bones. A strong caudal fluke is developed and help the animal in propelling its body and to the swim. Two mammae, one on each side are present near the arm pit of adult females. Nipples are about 25-30 mm in the adult females. In the male dugong, the urino-genital opening is situated away from the anus whereas in the female both openings are close. Bones are massive. It helps the animal to remain at the bottom of the sea. The brain of the dugong is small. Cerebrum has a few shallow sulci on temporal, parietal and frontal lobes. The corpus callosum is well developed. Pineal gland is absent in dugong. The kidneys are elongated. The ureters are dipelvic. In the males, testes are present posterior to the kidneys. Penis of the adult measures 20 - 25 cm in length. The ureters of dugong is bicornuated and the placenta non - deciduous.

Under the skin of the dugong is the blubber or fat layer constituted by fatty adipose tissue. It is useful to regulate the heat and protect the internal parts of the body from cold.

The female dugong gives birth to one calf at a time. The foetus of the dugong may be about 90 cm. Dugong are monogamous. It matures at a length of about 2.3 m.

Mandapam Regional Centre of the Central Marine Fisheries Research Institute has the distinction of keeping the dugong in captivity for 10 years. It was observed to grow 47 cm

during this period. We do not have much information on its longivity. The longvity of the animal may be about 40 years.

Dugongs are herbivores. They feed on sea - grasses found in the coastal waters. The sea grasses ***Cymodocea ciliata, C. isoetifolia, Enhalus koengi, Halophila ovalis, H. stipulacea, C. rotundata*** etc. form its main food. They are voracious feeders. 25 kgs of sea grass was taken from a dugong's stomach at a time. Dugongs browse at the bottom of the sea uprooting the rhizome of the sea grass.

Sea grass beds are found mainly off Mandapam in the Palk Bay at about 5 kms. in length and 150 to 300 m in width. Near Hare Island and Manoli Island the seagrass beds are found as scattered patches. Luxuriant growth of ***Cymodocea serrulata*** is found from near Thondi to Athankarai. Near Sethu Karai also vast meadow of seagrass is found.

Gulf of Mannar is characterised by a chain of twenty Islands and eighty one slightly elevated pearl banks locally known as 'paars'. Some of the islands are Vantivu, Velangu tivu, Musal tivu, Pallivasal tivu, Pulli tivu, Krusadi tivu etc. Dugongs occur in the seagrass beds found near the islands.

As the seagrass beds are the main habitat of the dugong, any natural or man made degradation to the seagrass beds will be affecting the dugongs. Apart from the impact of bottom trawling, cyclones, tidal waves, flood and the effluents also can degrade the seagrass beds.

Heavy damage was caused to the seagrass beds of Palk Bay in 1954 cyclone. The tidal waves of 1958 1964 and 1978 also have caused extensive damage to the seagrass beds of Gulf of Mannar and Palk Bay. It may be mentioned that during 1964, a tidal wave of 3-5m high struck the Rameswaram island washing away Dhanushkodi Island. Flood damage to these grass beds are well documented in India and Australian Coasts.

It was observed that many carcass of dugongs were washed ashore after the 1954 cyclone.

The dugong population of Gulf of Kutch is under great stress due to the development of petrochemical industries and disturbances to the ecosystem caused by the effluents. Many large industries are located in Tuticorin and their effluents are let into the Gulf of Mannar. 38 Dugongs in Saudi Arabia died after the Gulf war.

In India the gillnets are the major cause for the depletion of dugong population . In Tamilnadu there are about 1.18 million gillnets each measuring 2-3 kms. Gulf of Mannar has about 86202 gillnets and the Gulf of Kutch 7382. Between 1971-1975 as many as 146 dugongs were caught in Palk Bay and Gulf of Mannar. The mortality was about 30 per annum. It is very high rate of mortality. There might have been many unrecorded catches. 100-150 dugongs were caught annually in Gulf of Mannar part of Sri Lankan coasts. Gill nets, spears and dynamites have almost exterminated the dugong poulation. Being a sluggish animal it was an easy target for the fisherman. Further as medicinal properties were attributed to its meat, there is a good demand for it.

The dugong population of Gulf of Mannar and Palk Bay were under severe fishing pressure. There was a good population before 50 years. Meat of dugong was sold at Keelakarai regularly. They were using large gillnets namely 'Avuli Valai' having a mesh size of about 15-18cm for fishing the dugongs. These nets measured about 1.5 to 2.0 km in length and 5-7m in depth and was made of cotton twisted twine or twisted acacia sticks of about 2.5mm thickness.

It can be said that the dugong population of Gulf of Mannar is on the verge of extinction. Fisherman also say that they do not observe the dugongs now . All these observations indicate the dugongs of Gulf of Mannar and Palk Bay are becoming rare.

It is essential to conserve the dugongs of Palk Bay & Gulf of Mannar. The Indian wild life protection Act 1972 offers protection to this animal. But the law not properly implemented by the enforcing authorities. The dugongs were killed as enough awareness was not created among the fisherman and the coastal population. Intense awareness programme is this only way to protect the animal though they are rare

Sethusamudram ship canal project in the Gulf of Mannar Marine Biosphere Reserve - Its impact on Environment.

A.C.C. Victor

Regional Centre of Central Marine Fisheries Research Institute,
Marine Fisheries - 623 520, Ramanathapuram Dist., Tamilnadu.

The Gulf of Mannar is located on the southeastern tip of India in the State of Tamil Nadu. It is in this region India's first and foremost Marine Biosphere Reserve is located. Popularly known as the Biologists paradise, this region harbours more than 3,600 species of plants and animals, making it one of the world's richest marine biosphere reserves. Owing to its shallowness, semienclosed nature, less fluctuating temperature regimen, biophysical and ecological uniqueness, nutrient enrichment etc., it has acquired special status in the bio-diversity map of the Indo-Pacific oceanic realm. In recent years, the Government of India has been taking steps to initiate the excavation of the Sethu Samudram ship canal in the Rameswaram Island to connect the Palk Bay with Gulf of Mannar to facilitate the passage of ships without touching Colombo and circumnavigating Sri Lanka. In the budget for the year 2000-2001, the Government of India has sanctioned funds of Rs.4.8 crores for a detailed feasibility study and environmental impact assessment of the project. While the Government of Tamilnadu has expressed its happiness over the undertaking of the project, some environmentalists have raised questions on the positive and negative impacts of the project. The primary objective of this article is to analyse the positive and adverse aspect of the project.

A total of 21 islands are located in the Gulf of Mannar Biosphere Reserve between Pamban in the north and Tuticorin in the south. These islands lie on the proposed Sethusamudram ship canal zone and are located at a distance of approximately 1 to 4 km off the shoreline along the 150-km long coastline. These islands give protection to the mainland from the effects of wind and wave action especially during the northeast monsoon period when the wind velocity in this region exceeds 50 km per hour.

There are about 1 lakh people living in the 127 fishing villages located along the Sethusamudram Ship Canal zone, of which 87 villages are in the Palk Bay zone and the remaining 40 in the Gulf of Mannar zone. The people from these villages make their livelihood solely through fishing, seaweed collection and marine based industries. The annual marine fish catch in the Gulf of Mannar - Palk Bay zone is around 78,500 tonnes per year.

This Biosphere Reserve has been chosen for inclusion into an action programme to save India's protected areas on the basis of its threatened status and richness of biological wealth.

This Reserve has also been selected as an International priority-site on the criteria of its bio-physical and ecological uniqueness, economic, social, cultural and scientific importance, national and global significance. The probable impact of the shipping canal during the construction and operational phases need examination mainly on habitat destruction.

It is very important to note that any type of methods employed to dredge/break the substratum would result in increased silt formation and turbidity. Too much of silt load present in seawater prevents sunlight reaching of the sea-bed, thereby harming primary productivity.

Primary productivity the only means of synthesis of organic matter is the basis to tropic web. Thus any damage to the lower level would reflect at the higher level where the fishery exists. If sunlight does not penetrate into the sea for days together, darkness would prevail on the bottom, which adversely affect the photosynthetic activity of the symbiotic algae in the molluscs and corals. Further when silt gets deposited on all living organisms especially on sedentary biota - viz. pearl oysters, corals, algae, gorgonids, other molluscs, annelids, prochordates, echinoderms, the egg mass of many free swimming animals etc, they get destroyed since these organisms have no/little locomotive power to move away from the dredging zone. Deposition of silt bury many small living organisms. Silt enters into the gills of the animals and impairs respiration. Silt also affects the planktonic life. Siltation affects the solubilization of oxygen and gas exchange due to mineralisation and pH changes and, thus, the amount of dissolved oxygen in the water is reduced. Owing to the destruction of seagrass and seaweed beds, larger animals such as dugongs, turtles and herbivorous fishes are also affected. It is true that the dissolved components of the silt would enrich the algal growth and trigger the planktonic bloom. But this blooming may not be of much use since the benthic and other fauna, which mainly feed on them, are either not available or destroyed owing to silt deposition. The actual method proposed for breaking/dredging the bottom is not known. However, if blasting is resorted to, the resultant shock waves would adversely affect the fauna and flora of the Gulf region. When underwater rocks are dynamited, depending on the size and type of explosives used, almost all the plants and animals living at and around the site will perish and those living on the vicinity of the site will also be affected by the shock waves emanating from the blast.

Whatever may be the method of breaking/dredging that is employed, the sediments removed from the sea bottom would get dumped or spread adjacent to the canal. This would form as a mat and bury all the fauna and flora into it. Adverse effects are also to be expected from pollution owing to the use of machinery for construction and functional units. Spillage of oil and grease, rust and metallic wastes due to wear and tear, marine litter, float, sam and Jetsam including plastic bags, discarded articles would be the major pollutants.

During the operational phase, the frequent ship movements in the canal and dredging of the canal enhances turbidity, oil spill, besides emptying of bilge water, marine litter may have many negative impacts. The Gulf of Mannar Biosphere Reserve supports a very fragile ecosystem and this will affect the fauna and flora of the region to a very great extent. Therefore, the negative impact mentioned supra can be avoided by carefully, judiciously containing turbidity and pollutants both during the constructional and operational phase.

Excavation of the canal in the Adams Bridge sector would provide a deeper passage in the sector, which is shallow at present, and serve only as a barrier. Underwater currents play a significant role, not only in the transportation of large marine organisms, planktonic biota, fish eggs and larvae but also on shore dynamics, especially of the islands, reef and paars. Strong current would erode the banks of the canal and carry the sediments from one sector to another, which ultimately results in accretion of sand in one sector and decretion in another sector. Once the canal is deepened, the passage would greatly increase the movement of fishes and other large animals from Bay of Bengal to Indian Ocean and vice-versa. Hence, the entry of oceanic and alien species into Palk Bay and Gulf of Mannar and also disposal of endemic species outside Palk Bay and Gulf of Mannar would be facilitated.

On completion of the canal, the fishing in the canal should be restricted and properly regulated under expert guidance. At the sametime, these fishermen, being seafarers, might find increased opportunities in sea/ mercantile marine-based jobs.

There is good possibility for cultural / archaeological artifacts being brought up while dredging for the canal. Therefore, organisations like the Tamil University, Thanjavur, the Department of Archaeology of the State of Tamilnadu, the Department of Ancient History and Culture, University of Madras, Chennai and the Archaeological Survey of India, New Delhi should be co-opted to observe the excavation so that the artifacts can be retrieved, identified, studied and kept under safe custody.

Agriculture is very poor in the districts adjoining the proposed canal. Droughts are frequent. There are no major agricultural or mineral based industries here The construction of the project would strengthen the security of the country and enhance its economic development through maritime trade and income from service industries connected to shipping. Once the excavation of the canal is completed and the project is implemented, this would facilitate the passage of ships without going around Sri Lanka and touching Colombo, while the distance traversed between the ports of the east coast and those of the west coast would be reduced considerably. The implementation of the project would encourage many industries to come in the Districts of Tuticorin and Ramanathapuram. The Tuticorin Harbour will become one of the world's leading harbours in the entire South East Asia because of the increased trade and commerce. The implementation of the project would also put an end to the travails of the fishermen off Rameswaram coast, as they would get more protection for their endeavours and will also get alternative means of employment.

Marine Pearl Culture

D.Kandasami
Regional Centre of Marine Fisheries Research Institute, Marine Fisheries -623 520, Ramanathapuram District, Tamilnadu.

Pearls are one of the gems which has a worldwide demand and has been exploited from the time immemorial. Pearl fishing was prominent all over the Middle East and Oriental countries during the early 4000 BC. The use of pearls as ornaments was well exhibited in the Egyptian civilisation as well as Sind Valley civilisation. Based upon the demand the Romans and Greeks had trade with Gulf of Mannar Coast (Tamilnadu) and Gulf of Kutch (Gujarat). The entire trade was totally depending on the natural pearl resources causing heavy of damage to the natural populations. To produce a pearl by the pearl oysters bit required at least 3 to 4 years unter natural conditions. The percentage of natural pearl formation was very small. The production of spherical pearls by the oysters in nature is rare. Kokichi Mikimoto, in 1893 produced few blister pearls in the Japanese pearl oyster ***Pinctada martensii (P.fucata)*** at the coastal village of Jinmiyonmura on Ago Bay. In 1907 Tokichi Nishikawa produced the first spherical cultured marine pearl in the oyster and the pearl culture industries started flourishing with a master touch of Mikimoto and several others. After the World war II pearl culture industry was established in Australia, Philippines, Burma (Mianmar), Thailand, Malaysia and Indonesia with Japanese collaboration. The 'paar' of Gulf of Mannar have yielded very valuable fisheries in past, since 1955 and then the beds have gone unproductive.

James Hornell as early as 1916 paved a way for the idea of pearl culture in India and Ceylon. Some experiments were conducted in Krusadai Island (Gulf of Mannar, Tamil Nadu) since 1938 and in Sikka (Gulf of Kutch, Gujarat) since 1958. The success in developing the technology of pearl production was achieved only in 1973 when the first batch of free spherical cultured pearls was produced at Central Marine Fisheries Research Institute, Tuticorin.

Records of pearl oyster resources and pearl fishery in India.

1835 - (Madras Coast Records) Feb - March 1834 - Jadhi Thalaivan - discovered 34 beds between Kootapuli - Kooduthalai (Cape Comarin) Clandestine fishing by fishermen depleted the stock.

1836 - Lt. Col. Monteitha , Superintending Engineer reported the occurrence of two and a half to three and a half year old oysters from Thollaiyar paar.

1839 - Mr. Franklin appointed for the inspection of pearl banks, 12 banks - Vaipar to Mookur, 21 banks - off Tuticorin, 24 banks - off Punnakayal, 14 banks - off Tiruchendur. Out of the above 21 banks of Tuticorin considered for good fishing grounds.

1841 - Mr. Franklin - reported that pearl oysters had disappeared from the beds, possibly due to natural causes.

1848 - Mr. Thomas, Collector of Tirunelveli - suggested the leasing of pearl banks to a wealthy merchant on 50-50 basis to check the poaching. Suggestion dropped. But 1849 report confirmed the fear and the entire oyster had disappeared.

1856 - Due to Suram - no oyster bed was found.

1858 - Results of inspection

recommended the possible fishery, during 1860 from 23 beds.

1860 - A pearl fishery from 23 beds off Tuticorin for 23 days. Yielded a gross revenue of Rs.250276.00

1860-1864 off Tiruchendur - 5 years old oysters found plenty reported by Captain Phipps after 21 days survey.

1866-67 'Paars' inspected only off Punnakayal with one year old stock.

1867 - 66 'Paars' were inspected during Jan-Mar. Young oyster settlement was seen in 15 of the 'Paars'.

1870 - Poaching was found near Nallathanni thivu - finding heaps of pearl oyster shells. People of Kilakarai and Valinokkam might have plundered the oyster beds - sparked big controversy.

1873 - Off Tuticorin banks - with very large quantities of young oysters were attached to the rocks and weeds.

1876 - Out of 18 banks - 5 'Paars' gave hope of fishery in 1878 - 1880.

1885 - GW Wicks completed inspection of 46 'Paars' are found off Tuticorin fit for conducting fishery.

1923 - Based on MT Lady Nicholson report fishery forecast for 1927 - 28.

1926 - 24 crores of oysters were estimated for fishing during 1926 with a 770 sq. miles area.

Declaration of rules under 6 of the Indian Fisheries Act of 1897 was made into effect for the prevention of poaching.

1927 - 29 Pearl fishery was in full swing Feb-Mar-33 days harvested, 14,096,839 number of oyster, Nov. - Dec. - 23 days, harvested, 1,608,931 oysters in Tholayiram paar.

Feb.-Apr.-27-days, harvested 10,337,050 oyster special feature of this fishery was the participation of 38 Arab divers. Dec 27- Jan. 28 of 7 days. and Mar-29-31 days - 9.6 million oysters harvested.

1937-Pearl oyster farming started near Kunthukal point at Krusadai Island

1940-74,519 oysters collected from Thanjavur and transported to Krusadai.

1941 - A total of 6782 pearl oysters were farmed and initiated pearl culture.

1956 - April to May - 3.058 million oysters from Tholayiram 'Paar' was collected fetching a revenue of Rs.1,46,000.00

1957 - Pearl fishery was continued for 51 days, 11,175 million oysters near Kudamuthu paar. Punnakayal, Tiruchendur paars 21 days fishing 8.3 million oyster.

1958 - 14 March - 26th May - 55 days - 21,476 million oysters from Kuruval paar.

1958 & 59 Dec. - Jan - 36 days 10.738 million from Kuruval paars.

1959-60 - 22 million oysters estimated in Tiruchendur Tholayiram and Kudamuthu paars.

1960-61 A total 16.175 million was fished.

1963-13 banks of Tholayiram 'paar' and Kuthdiar 'paars' estimated to be 20 million oysters reported by P.B.Salvadori. A total of 16.176 million oysters fished out for 30 days.

Pearl formation - Natural

The formation of pearls in the pearl oyster is due to the pearl secreting cells of the mantle migrating into the body of the oyster under the stimulus of a foreign body and by a series of cell division form a pearl-sac around the foreign body. The pearl-sac in turn secretes the nacre over the body , forming a 'natural pearl' in course of time.The natural pearl formation can occur with or without a nucleus. The formation of blister pearls also possible when a particle stick to the shell near the mantle tissue and due to irritation the nacre is secreted over the particle and forms a blister pearls.

Spherical pearl formation

The formation of spherical pearls in pearl oysters can be achieved by introducing a spherical nucleus into the gonad of the oyster along with a small bit of mantle tissue. The mantle tissue known as graft tissue introduced into the gonad start growing and forms a pearl sac, which secretes nacre over the nucleus and forms a pearl.

Pearl oyster resources in India

Distribution

Pearl oysters belong to the genus ***Pinctada.*** They enjoy a world wide distribution occurring in almost all the seas of the tropical and subtropical region. Six species of pearl oysters occur in the Indian waters viz. ***Pinctada fucata*** (Gould), ***P.margaritifera*** (Linnaeus), ***P.chemnitzii*** (Philippi), ***P.sugillata*** (Reeve), ***P.anomioides*** (Reeve) and ***P.atropurpurea*** (Dunker) of which ***P.fucata*** alone contributed to pearl fisheries in Gulf of Mannar and Gulf of Kutch.

The pearl oysters always found attached by byssus to some hard materials such as rocks, dead corals, outcrops or sand grits covered with marine organisms. In Gulf of Mannar the pearl oyster occurring area is known as pearl banks or 'paars'. There are 65 such pearl banks located between Kanyakumari and Rameswaram Island. These banks stretch between 12 to 20 km away from the coast at a depth of 15 to 25 meter. These paars were divided into three divisions. Northern or Kilakarai division extensively from Adam Bridge to Vaipar. The central division extends from Vaipar to Manapad and the southern or Kanyakumari division stretches from Manapad to Kanyakumari. Only central division is most productive because out of 40 fisheries (between 1663 and 1961), 39 fisheries had been taken place in this division.

In the Gulf of Kutch, the pearl oyster reefs are scattered along the southern part of the Gulf of Kutch. There are about 42 known pearl oyster reefs covering an area of 24,000 ha located between Sachana on the east and Ajod on the west. The beds are located in the inter-tidal region and are exposed at receding tides, known as 'khaddas'.

The black lip oyster ***(P.margaritifera)*** is confined mostly to Andaman waters. From Lakshadweep, settlement of spat of ***P.fucata*** and ***P.margaritifera*** are found on the ridges of rocks and corals.

Collection of Pearl oyster spat

Collection of pearl oysters from the natural beds is not always dependable due to their irregular production patterns. Three ways of collection of spats are there. They are (i) setting up of artificial spat collection at subsurface during oyster spawning seasons (ii) collection from natural beds and (iii) hatchery production. There are several practices for spat collection in different part of the world. In Japan shells of abalones, oysters and scallops and cedar springs are suspended from the rafts from just below the surface to about 3-m in depth for collecting the spat of pearl oysters. Similarly, the rope collectors, synthetic filamentous spindle, split bamboo collectors and coconut shell strings were used .

Pearl oyster hatchery technology

Central Marine Fisheries Research Institute has developed technology for hatchery production of pearl oyster *(P.fucata)* spat which is an important milestone in the progress of reseat and development in marine pearl culture in India.

Site selection

The primary requirement of an operational hatchery is the uninterrupted supply of good quality seawater, free from pollution. The seawater used for the hatchery should be free from suspended particles. The site for the water intake should be rocky coralline or sand mixed. It should be away from domestic or industrial sewages. The site should not be very close to river mouths, which may cause fresh water influx during flood resulting in low saline water. Other aspects to be considered are proximity to the natural resources and farm sites and logistics for transplantation.

Hatchery building

Hatchery building must have light control facility, and free air passage inside the hatchery. Water intake, outlet, drainage facility should be provided in order to prevent the water stagnation inside the hatchery. The flooring must be either concrete or granite or 'kadapa'stones, which provide a solid bottom, with gentle slope for easy washing and draining of spilled seawater.

Water source

Clean and pollution free seawater supply to the hatchery is very important. The water supply to the hatchery should pass through biological filters or high pressure sand filters initially and later to UV filter. PVC pipelines has to be used in order to avoid metal contamination of the water supply.

Aeration

The aeration can be provided by centrally fixed air compressors or air blowers. Air blowers are more suitable than the air compressors because the oil used in the air compressor may contaminate the quality of air. PVC pipe lines, tubes and regulators are to be used. Air stones must be provided to diffuse the air.

Brood stock maintenance

Brood stock maintenance is an important component for successful hatchery production of pearl oyster spat. The brood stock was brought to the laboratory from the open sea and maintained at 25-28°C. The oyster is fed with mixed micro algae. The brood stock is kept on a rectangular shallow FRP tanks (100 x 50 x 20 cm), filled with a small platform at a height of 5 cm to keep the brood stock oyster which makes easy for cleaning the faecal matters without disturbing the mother oysters.

Natural Spawning

The pearl oysters with matured gonads naturally spawns when there is slight change in the medium. In all the cases male will get induced first and release the spermatozoids, which triggers the female to release the eggs.

Induced Spawning

In order to operate the hatchery continuously, it is essential that induced spawning to produce larvae at required time is very important. There are different types of techniques applied to induce the oysters to spawn.

Chemical Induction

Hydrogen Peroxide at a dosage of 3 to 6 millimole induces spawning of 18.2% after 2 hours.

At pH 9.0 using the buffer 37.5% spawning can be achieved after 1-2 hours.

Thermal Induction

The thermal shock method found to be very safe and effective. When the brood stock

is kept at lower temperature 25-28.5°C and they are gradually exposed to 35°C the matured oysters respond due to the thermal shock and spawning process takes place.

Larval Development

Soon after the discharge of both male and female gametes the fertilisation takes place in the water media. The unfertilised eggs, after fertilisation attain spherical shape with an average size of 47.5µ. The first and second polar bodies appear. The first cleavage appears at 45 minutes after the fertilisation resulting in a micro mere and macromere and is called Trefoil stage. Then develops a small cilium, which makes the rotation movement of the embryo. Blastula is reached after 5 hours of the fertilisation; the formation of blastopore and blastocoel takes place within this stage. Gastrulation takes place by epiboly. The archenteron formed at this stage. The embryo exhibits phototropism during this stage. It takes 7 hours to reach the stage from the time of fertilisation. A tuft of cilia of preoral and postoral develops this making to the anterio - posterior region of embryo. It takes 10 hours to attain trochophore.

The veliger stage is reached by the formation of the straight hinge line, mantle rearrangement of preoral cilia into a velum and disappearance of the apical flagellum, preoral ciliary bands. The size of the larvae is 67.5 µ and it takes 20 h to reach the stage. The development of straight hinge larvae to umbo stage is gradual. Typical clam shaped umbo stage reached between 10-12 days. The mantle fold also develops in this stage. Eyespot is developed on the 15th day when the larvae reaches 190 x 180 µ in size. The eyespot is situated at the base of the foot primordium.

The foot is developed on the 18th day at the size of the 200 x 190 µ. This is a transititionals stage between swimming and crawling. Later the foot becomes functional and the velum disappears. 2-4 gill filaments are seen.

Plantigrade stage is reached on the 20th day and measures 220 x 200µ. Labial palps and additional gill filaments develop. Shell growth is visible.

Plantigrade transforms in to young spat. Hinge line, anterior and posterior auricles and the byssal notch assume specific shape. The left valve is more cancave than the right. The spat attaches to the substratum by means of byssal threads.

Feeding regime

First feeding starts at veliger stage and at this stage the larva require 5000 cells/day/ larvae. ***Isochrysis galbana*** forms the intial food. From 10-12 day the quantity is increased to double i.e. 10,000 cells/days/larvae and continued to 15th day. From 15th day, the feed is increased to 20,000 cells till the pediveliger. Spats are fed with mixed culture of ***Isochrysis galbana, Nannochloropsis*** and ***Chaetoceros*** spp with a domination of ***Chaetoceros*** in the culture.

Live food culture

Flagellates measuring less than 10µ forms the food of pearl oyster. The important phytoplanktons are ***Isochrysis glabana, Pavlova, Chromulina*** and ***Dicrateria*** spp. The most common method followed in the pearl oyster hatchery for stock culture of ***Isochrysis galbana*** is by using Walnes's or Conway medium.

Mass culture

From the stock culture, mass culture of micro algae produced at room temperature in 20-40 l tanks (Perspex). The composition of the medium used for the mass culture and mixed culture of algae is

Potassium nitrate	- 0.4 g
Potassium dihydrogen ortho phosphate	- 0.2 g
Sodium Silicate	- 0.2 g
EDTA sodium Salt	- 0.2 g
Filered seawater	- 30.0 l

Microalgal culture condition

The right amount of illumination is an important factor for the microalgal culture. Most of the flagellates require less light during the stationery phase. High light intensity may cause early declining of culture. The ambient levels of light is 1000 to 1500 lux for 4-5 days and for maintaining the stock further limited to 400-500 lux. Photoperiod of 12h day and 12 h dark is necessary for both stock and mass culture of microalgae at 23-25°C. Aeration is necessary for the mass culture of microalgae.

Nucleus implantation technique

Selection of oysters

Selection of mother oysters for the purpose of nucleus implantation is very important. The mother oysters must have ideal stage of gonad for the operation. Immature and maturing stage oysters are suitable. The oozing oysters are not suitable for implantation

Graft tissue preparation

The peripheral mantle portion of few healthy oysters are cut and removed. This mantle stripe is trimmed and 2 mm square pieces are cut. The graft bits are placed in filtred sea water and a small amount of Eosin stain is added.

Nucleus implantation

The oysters are fixed on a stand with a clip and the gonad region of the oyster is located and a small incision is made at the base of the food and taken into the gonad. A small twist is made while making the incision which will prevent the ejection of the nucleus. Then the operated oysters are sent to filtered running seawater tanks for a post operative care for three days and subsequently the oysters are ready for transplantion .

Farming methods

Raft culture

This method is found to be most suitable and appropriate one to farm the oysters in the sheltered Bays. Wooden poles lashed with coir ropes and floated with the help of buoys moored by 2 to 4 anchors tied by means of 15 mm nylon ropes. Wooden barrels, empty oil drums coated with M.S.Sheet barrels, Polythene barrels and FRP coated foam material are used as floating buoys for the purpose. A raft of 6 x 5 m is found to be more ideal for the pearl oyster culture and can accommodate 80-100 cages of 40 x 40 x 10 cm in size.

Collapsible or long line raft

A collapsible or long line raft comprised of 16 to 20 empty PVC barrels (200 litre capacity) arranged in a row or 4 rows connecting one another by a chain stretched and anchored to all the ends. Between the gaps, the pearl oyster cages are suspended. The collapsible cages are very convenient for erection and removal. The disadvantage of this type of raft is that the suspended cages get entangled during the rough weather and get damaged due to hitting with one another.

On bottom culture

This type of culture technique is possible only on the rocky sea bottom or artificial bottom either made up of old net materials spread on the bottom or by pavement of old pearl oyster cages over which old net materials are spread and tied at the corners by means of a erected poles. This is necessary to prevent the migration and falling of pearl oysters on the muddy bottom. In an area of 100 x 3 m, 300 oyster cages can be kept. This type of culture can be applied as a temporary means to accommodate the wild collected oysters before farming into off shore rafts.

Rack System

In this method, 3" dia GI pipe materials or 5" bottom casurina or eucalyptus poles erected at a depth of one metre into the soil in the sea with 2 to 3 m depth of water column at low tide. The gap between the poles is 3 m and they are

erected at a row of 3 or 4 into the sea. The poles are cross connected by means of wooden poles and tied by means of coir ropes. The gaps are inter connected by the same poles in order to accommodate 80 to 100 cages per compartments. This can be extended to a long distance more than 200 m from the shore to a depth of 3 to 5 m into the sea. This type of rack method culture system is very convenient for the operation and also to attend the farming work easily.

Environmental parameters

The growth of the oysters or spat totally depends on the primary producer's. The colour of the pearl is strongly affected by the water temperature, food availability, physiological conditions of the pearl oysters. But the bloom of ***Trichodesmium thiebautii*** may cause heavy damage to the pearl oyster.

The temperature plays an important role in the biological activity of pearl oyster, in Indian waters the ambient temperature is 25-30°C. The pearl oyster prefers high salinity but oyster raised in such water produces pearls with golden tint. The pearl oyster can tolerate with range of salinity from 25 to 40%. Beyond this levels the oysters may not survive for longer period. The pearl production depends on the depth of the water and usually 15-20 m the growth of the oyster found to be very good. But the minimum depth required for a good quality pearl is 5 m, which produces pink colour pearls.

In addition to the above factors, the bottom of the sea, water current, proximity to river flow and silt load, plays an important role to fix the quality of pearls.

Grades of pearls

Class A : Flawless, one flaw, small stain, pink silver or light cream; further categorised into A-1. Top pearls - perfectly round; pure, flawless and lustrous A-2. First class pearls with slightly large pits and protuberances.

Class B : Fairly large flaw, stains, cream colour, and irregularity in shapes.

Class C : Fresh pearls, wild shaped, badly coated, heavily pack - marked, and clayey lump half good and half bad.

Chemical composition of pearls (%) are as follows

Water	- 3.97
Organic matter	- 3.83
Calcite and aragonite	- 91.59
Loss	-0.61

Economics of pearl culture Raft Culture method
Raft size 6 x 6 m
Input cost (2 years)

	Rs.
1. Cost of poles , floats, anchors and anchor chain and ropes	13,000.00
2. Cages (100 Nos) for rearing 10,355 oyster	10,000.00
3. Cost of 10,355 oysters @ 1.40/seed	14,500.00
4. Cost of 9414 shell bead nucleus	9,500.00
5. Cost of chemicals & Glasswares & surgical instruments	5,000.00
6. Charges for pearl oyster surgery	3,000.00
	55,000.00

Production and revenue

Total pearl procured	1,849 Nos
1. Sale proceeds of 1296 pearls	Rs.73,133.00
2. Cost of 250 pearls distributed to fishermen in lieu of their	

labour	Rs.12,500.00

The remaining 303 pearls were of inferior quality and fetched low market price

The rate of return worked out 55.7%

(Source T.S.velayudhan, Technology Transfer Division Series 5).

Rack Culture

Total area	20 x 15 = 3000 sqm
	Rs.
Infrastructure facility farm	40,000.00
Cages (1000)	75,000.00
Rope and other accessories	30,000.00
Cost of oysters (1,00,000)	4,00,000.00
Nucleus	1,00,000.00
Cost of Labour (4 person - 12 months)	96,000.00
Watch and ward (3 persons)	54,000.00
Miscellaneous	15,000.00
Total expenditure	8,10,000.00

Revenue

Total No. of pearls harvested : 30,000

Class A 3000 nos and Class B 6000 Nos

On an average @ Rs.100/pearl	9,00,000.00
Class C 18000 Nos	3,60,000.00
Total	12,60,000.00

Source : ICAR Revolving fund project on pearl culture.

Shrimp culture during 1998 - 2000 at marine fish farm, Regional centre of CMFRI, Mandapam Camp.

G.Maheswarudu,
Regional Centre of Central Marine Fisheries Research Institute
Marine Fisheries - 623 520, Ramanathapuram District., Tamil Nadu.

With the introduction of trawlers in the Palk Bay and Gulf of Mannar during 1960s under Indo-Norwegian Project exploitation of shrimp began and it has reached commercial scale during 1970s as many private entrepreneurs initiated trawl fishing. The annual shrimp landings ranged from 1000 to 2000 tonnes during beginning of 1990s in the Mandapam region. In 1960s ***Metapenaeus affinis*** was the dominant species followed by *Penaeus semisulcatus*. Gradually ***M. affinis*** was replaced by ***P. semisulcatus*** and by 1970s ***P. semisulcatus*** was dominant species of shrimp fishery in this region. As shrimp catches are promising and fetching lucrative income, effort has gradually increased and the catch of ***P.semisulcatus*** has reached maximum sustainable level, and further increase in fishing effort by trawlers would lead to depletion of shrimp stock. The other source to augment the shrimp production is to adopt culture practice all along the coastal areas and to establish ranch fishery in the sea by releasing hatchery raised seed in large scale.

In 1987, CMFRI has taken up searanching programme under the leadership of Dr. P. Vedavyasa Rao, and ***P. semisulcatus*** has been selected as a candidate species for searanching. A backyard hatchery has been established with one million post larvae capacity. Technology has been developed for seed production of green tiger shrimp and ranching of juveniles continued since then. Seagrass bed areas in the Gulf of Mannar and Pillaimadam lagoon nearby Marine Fish Farm were selected to release hatchery raised seed. Observations made on movements of released seed have revealed that seagrass beds are most suitable nursery grounds for green tiger shrimp and juveniles released in the lagoon are migrated to Palk Bay immediately after one day from releasing in search of seagrass beds.

Tagging experiments were carried out during 1990-94 to assess the recruitment pattern of searanched population to the commercial shrimp fishery in the fishing grounds. Under this programme hatchery raised postlarvae were reared upto taggable size (100mm) in earthen ponds, marine fish farm, acclimatised to seawater for 2 h, tagged with ATKIN tags, acclimatised in the seawater for 2 hours again and survived juveniles were released into the Palk Bay where seagrass beds were dense. Tagging experiements have revealed that searanched population is surviving, growing and get recruited to the fishery. The same study also revealed that searanched population is maturing at the age of 6 months and spawning in the sea.

Besides this releasing of seed and tagging programmes, in 1988 experimental farming of green tiger shrimp has taken up in a small pond of 400 sqm area and PL_{25} were stocked at a rate of 5/sq.m. After 120 days of culture 7 kg of shrimp was harvested and the harvested size was 98.3 mm TL. Growth was progressed well during first 60 days and thenafter growth was stunted. The survival rate was 40%.

During 1993-94 experimental farming

was conducted in two earthen ponds of 800 sq.m. each. Seed was stocked at the density 5/ sq.m. and culture was carried out for 136 days. Stocked population was fed with Biofeed imported from Singapore. Water exchage was provided once in 15 days from the day 60. Harvested size was 124.11 mm TL/16.74g and 112.13 mm TL/11.95g respectively in pond 1 and 2. Survival rate was 43.4% in pond 1 and in the other it was 76.02%. FCR was 1:2 This experiement has revealed the potentiality of green tiger shrimp for adopting to commercial culture.

Commercial culture of green tiger shrimp was taken up during 1996 - 97 in 3 large ponds of 0.24 ha each. Each pond was facilitated with outlet made of 6" PVC pipe which was used for water intake from channel as well as to drain out from the pond. Water level in the pond was maintained at 0.75m depth by pumping water from channel. Seed was stocked at a rate of 60,000/ha. Stocked population was fed with pellet diet supplied by M/s. C.P. Aquaculture (India) Private Limited. This experiment was ended with a tragic incident, which could not be explained. The harvested size ranged from 119.8 mm TL/14.3g to 129.5 mm TL/18.8g after 150 days of culture. The generated revenue was Rs.25,564.

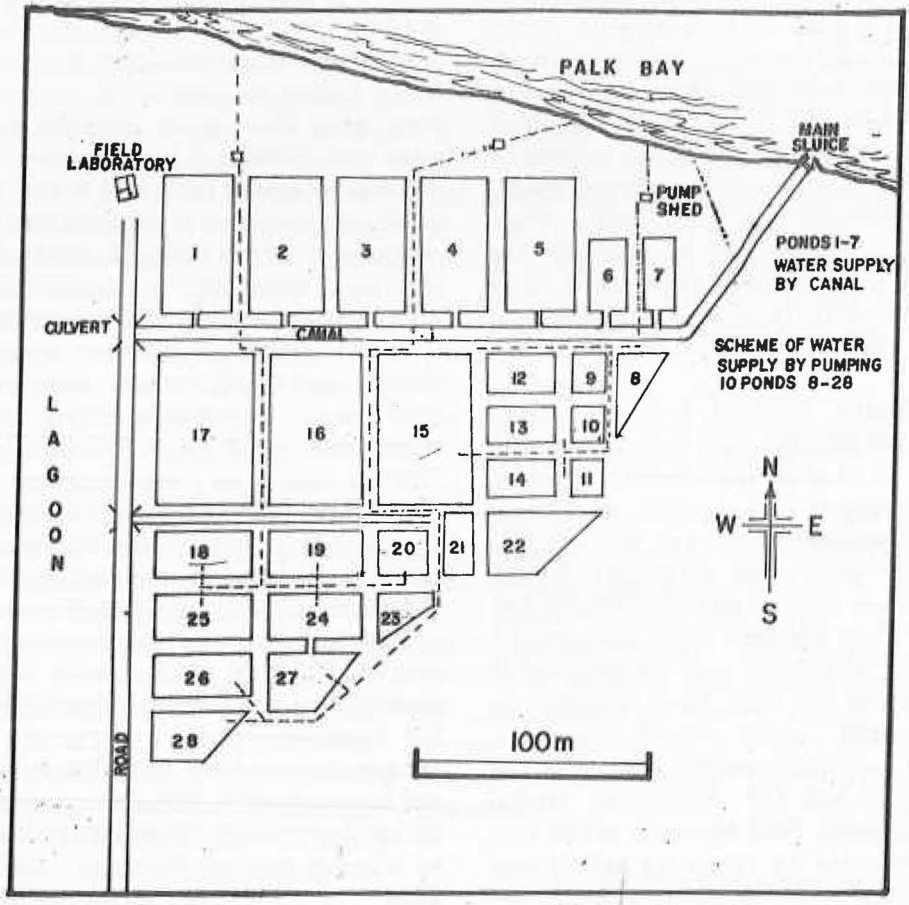
During 1997-98. 6 earthern ponds (0.99ha) of different sizes were stocked with 51.000 PL20 of ***P. semisulcatus.*** Stocking density ranged from 3/sq.m. to 6/sq.m. Temporary seashore well was dug and piled with sand bags in the peripheral region. Seawater was drawn to the sump by laying four 6" PVC pipes. Kirloskar diesel pumpset (14.5 HP) was established near the sump and 6" pipeline was laid from diesel pumpset to experimental ponds (No.15,16 and 17). Stocked population was fed with pellet diet supplied by M/s. C.P. Aquaculture (India) Private Limited. Field laboratory at Fish farm was renovated by removing ceiling and establishing roof with palmyra beams and asbestos cement sheets. Single- phase electricity supply was reestablished. After 145 days of culture harvest was carried out and 659.4kg of shrimp was caught. Production rate varied from 163 kg/ha to 1040 kg/ha. A sum of Rs.93,022/- was generated from the sale of shrimp.

During 1998-99, constructions of sluices were made for 3 ponds (15, 16 and 17). Slopes for the same were also constructed at the place of water inlet. Modified pond No.18 (0.35ha), 19 (0.32 ha) and 20 (0.15 ha) were made by merging small ponds (18,25 &26; 19. 24 & 27; and 20, 21 & 23) of different sizes. Pond bottom of these three ponds was raised up to 35 cm height by placing the soil that brought from the lagoon. Combine drain out sump was constructed for the pond 18 and 19 and 14.5 HP diesel pump set was fixed to provide effective water exchange through pond No.22. Surface drain out facility was provided from pond 22 to lagoon. Seawater drawing sump was constructed in the seashore with two lines of cement pipes of 2 ft dia. Pump house was cosntructed to accommodate diesel pumpset (14.5 HP) as well as electrical pumpset (12.5 HP). Water delivery pipeline was laid from electrical pump set to pond number 18, 19 & 20. Three phase electricity supply was obtained and 7 paddle wheel aerators were fixed in six experimental ponds. Shrimp culture was carried out in 7 earthen ponds. This year besides the green tiger shrimp, black tiger shrimp ***P. monodon*** was initiated with the aim of developing a viable technology for brood stock development in captivity. Out of 7 ponds, two (0.5 ha) were stocked with PL 29 of ***P.semisulcatus*** and the remaining five were with PL 15-20 of ***P.monodon.*** Stocked population was fed with commercial diet of C.P. Aquaculture (India) Pvt. Limited. After 150 days of culture totally 3,516.75 kg of shrimp was harvested and Rs.9,03,426/- was generated through sale proceeds of shrimp. Of the 3,516.75 kg of shrimp harvested, black tiger contributed 3,108.75 kg and 408.0 kg was by green tiger.

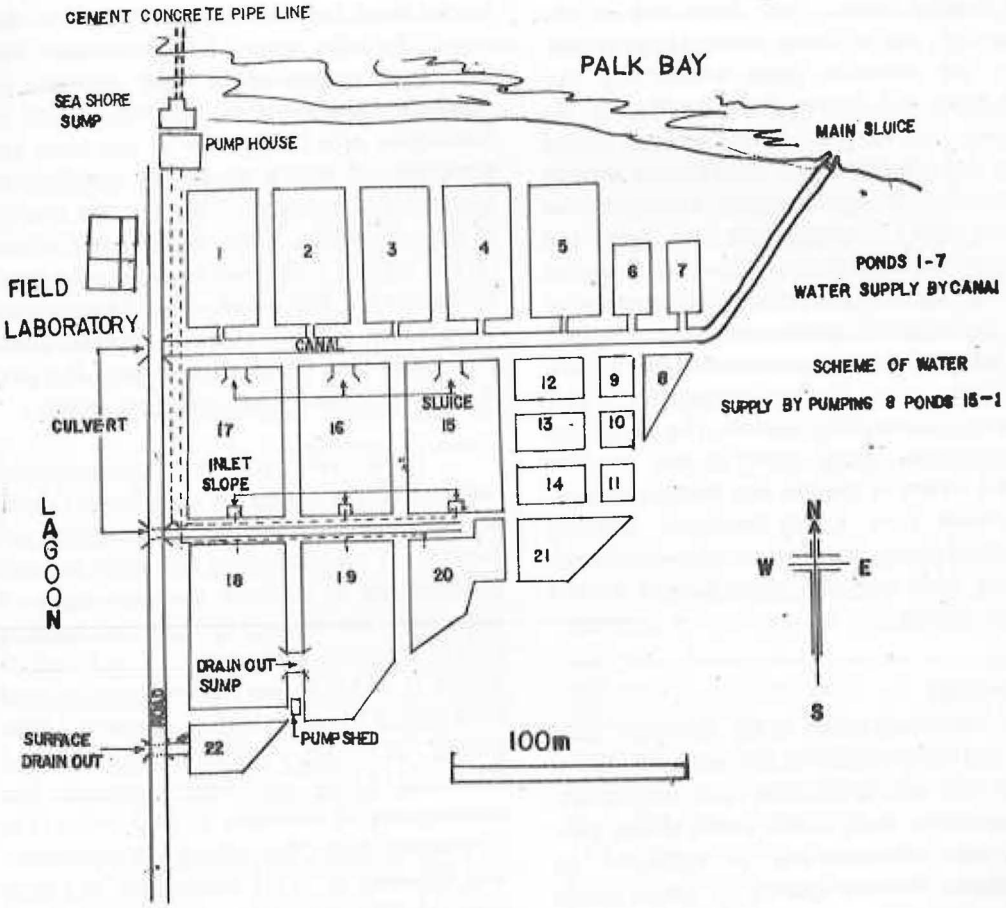
During 1999-2000 shrimp culture was practiced in 5 ponds of which 3 were with tiger shrimp, 1 with green tiger shrimp and the other with 3 shrimps namely black tiger shrimp, green tiger shrimp and Indian white shrimp. After 147 days of culture, 1,048 kg of black tiger shrimp was harvested from 3 ponds (0.75 ha). The production of green tiger shrimp was 59.0 kg from 0.15 ha pond. Polyculture experiment was conducted in 0.08 ha pond by stocking 3 Indian cultivable species to study the compatibility among them. After 90 days of culture, as black tiger shrimp was infected with white spot, harvest was done and production was 41.0 kg. Of the three shrimps stocked, only black tiger shrimp was infected which is revealing the fact that black tiger shrimp is more susceptible to whitespot compared to other two shrimps. Totally 1148 kg of shrimp was harvested and Rs.4,37,151 was generated.

The outcome of the experimental farming conducted during 1988-2000 is development of viable grow-out technology for green tiger shrimp and viable technology for development of broodstock of black tiger shrimp in captivity.

Map of fish farm before 1998
Regional Centre of CMFRI, Mandapam.



Map of modified fish farm,
Regional Centre of CMFRI, Mandapam.



Marine plants of Mandapam coast and their uses

N.Kaliaperumal
Regional Centre of Central Marine Fisheries Research Institute,
Marine Fisheries - 623 520. Ramanathapuram District, Tamilnadu.

Introduction:

In the sea 3 types of plants occur and they are Phytoplanktons, Seaweeds or Marine Algae and Seagrasses. Phytoplanktons are microscopic and free floating forms and they are the primary producers of the sea. Seaweeds or Marine Algae are macroscopic, attached or free floating plants. They form one of the important marine living renewable resources. They are primitive plants without any true root, stem and leaves. They belong to the Division Thallophyta of Plant Kingdom. Marine algae are classified into four groups namely Chlorophyceae (green algae), Phaeophyceae (brown algae), Rhodophyceae (red algae) and Cyanophyceae (blue-green algae) based on the type of pigments, morphological, anatomical and reproductive structures. Seagrasses are the marine flowering plants belonging to two families Hydrocharitaceae and Potomogetonaceae under the group Phanerogams. They grow in the shallow coastal waters in tropical and temperate zones. Seagrasses have a well developed creeping rhizome, bearing branched or unbranched roots at each node and erect shoot bearing several foliage leaves.

Seaweeds

Seaweeds occur in the intertidal, shallow and deep waters of the sea upto 180 m depth and also in estuaries and backwaters. They grow on dead corals, rocks, stones, pebbles, other substrates and as epiphytes on seagrasses. Several species of green, brown and red algae with luxuriant growth occur along the southern Tamil Nadu coast from Rameswaram to Kanyakumari covering 21 islands of Gulf of Mannar. In Gujarat coast seaweeds occur abundantly in Okha, Dwarka, Porbandar, Veraval, Diu and Gopnath areas. Rich seaweed beds are present at Mumbai, Ratnagiri, Goa, Karwar, Varkala, Vizhinjam, Visakhapatnam and coastal lakes of Pulicat and Chilka. Seaweeds also occur abundantly in Lakshadweep and Andaman-Nicobar Islands. More than 10,000 species of marine algae have been reported all over the world. In India about 220 genera and 740 species of marine algae were recorded of which 60 species are of economic value. In Mandapam area 180 species of seaweeds are growing, of which about 40 species are economically important. They are the species of ***Enteromorpha, Ulva, Caulerpa, Codium*** (green algae); ***Colpomenia, Hydroclathrus, Cystoseira, Hormophysa, Sargassum, Turbinaria*** (brown algae), ***Asparagopsis, Gelidiella, Gracilaria, Sarconema, Hypnea, Acanthophora*** and ***Laurencia*** (red algae).

It is estimated from the seaweed resources survey conducted so far by the Central Marine Fisheries Research Institute, National Institute of Oceanography and other research organisations at different maritime states of India and Lakshadweep that the total standing crop of seaweeds in the intertidal and shallow waters is 91339 tonnes (wet wt.) consisting of 6000 tonnes of agar yielding seaweeds, 16000 tonnes of algin yielding seaweeds and remaining edible and other seaweeds. The standing crop of seaweeds in deep waters (5 to 22 m depths) from Dhanushkodi to Kanyakumari was estimated as 75373 tonnes (wet wt.) in an area of 1863 sq. km. The biomass of economically important seaweeds of Gulf of Mannar is estimated as 8445 tonnes (wet wt).

Seaweeds contribute to primary production of the sea and hence seaweed beds

are considered to be highly productive and dynamic eco-system. Seaweed vegetation provides an ideal habitat, food and shelter to various marine animals. They act as breeding, nursery and feeding grounds for many epiphytic fauna. The hapteron or holdfast of marine algae binds the sediments together and prevent coastal erosion. The calcareous algae such as ***Halimeda, Acetabularia, Neomeris*** (green algae), ***Padina, Zonaria, Pocockiella*** (brown algae)***Liagora, Liagoropsis, Galaxuara, Scinaia, Actinotrichia, Amphiroa, Jania, Cheilosporum, Corollina, Lithophyllum, Lithothamnion*** (red algae) are responsible for the formation of coral reefs and atolls. Calcareous algae are also responsible for the formation of beach rock which is formed by binding of sand particles by calcite deposits.

Uses of Seaweeds

Seaweeds contain different vitamins, minerals, trace elements, protein, iodine, and boiactive substances. They are the only source for the production of phytochemicals such as agar (China grass), carrageenan and algin. Agar is extracted from red algae such as ***Gelidiella, Gracilaria, Gelidium*** and ***Pterocladia.*** Some other red algae viz. ***Eucheuma, Chondrus, Hypnea*** and ***Gigartina*** are used for the production of carrageenan. Algin is manufactured from brown algae like ***Sargassum, Turbinaria, Cystoseira, Laminaria, Undaria, Macrocystis*** and ***Ascophyllum.*** These phytochemicals are used as gelling, stabilising and thickening agents in food, pharmaceutical, confectionary, dairy, textiles, paper, paint, varnish industries etc. Other chemical products such as mannitol, iodine, laminarin, fucoldin are also obtained from marine algae.

Many protein rich seaweeds like ***Ulva, Enteromorpha, Caulerpa, Codium, Monostroma*** (green algae); ***Sargassum, Hydroclathrus, Laminaria, Undaria, Macrocystis*** (brown algae); ***Porphyra, Gracilaria, Eucheuma, Laurencia*** and ***Acanthophora*** (red algae) are used as human food in countries like Japan, China, Korea, Malaysia, Thailand, Indonesia, Philippines and other southeast Asian countries in the form of soup, salad, curry etc., In Japan, China and Korea ***Ulva, Enteromorpha, Monostroma*** and ***Porphyra*** are added in soup and ***Undaria*** and ***Laminaria*** are eaten in dried form. In Philippines ***Caulerpa lentillifera*** is consumed as salad while ***Codium tomentosum, Eucheuma denticulatum*** and ***Kappaphycus alvarezii*** in the form of curry. The seaweed food products such as jelly from ***Gelidiella*** and ***Gracilaria;*** jam from ***Ulva*** and ***Enteromorpha;*** pickle and wafer from ***Gracilaria, Hypnea, Acanthophora*** and ***Laurencia*** can be prepared and marketed.

The food value of seaweeds depends on the minerals, trace elements, protein and vitamins present in them. Marine algae have all essential aminoacids needed in the human diet which are not available in vegetable food materials. In India seaweeds are not eaten except the jelly prepared from agar (China grass) and porridge prepared from ***Gracilaria edulis*** in the coastal areas of Ramanathapuram District. Agar is added in the preparation of following food stuffs - Ice cream, Tomato Sauce, Jams, Jelly, Marmalade, Blancmange and Lime jelly.

Seaweeds are cheap source of minerals and trace elements. Hence meal could be prepared by grinding the cleaned and washed seaweeds. It can also be mixed with fish meal and used in different parts of the world as fertilizer for various land crops. In India, freshly collected and cast ashore seaweeds are used as manure for coconut plantation either directly or in the form of compost in coastal areas of Tamil Nadu and Kerala. Seaweed manure has been found superior to farm yard manure. The high amount of water soluble potash, other minerals and trace elements present in seaweeds are readily absorbed by plants and they control deficiency diseases. The carbohydrate and other organic matter present

in the marine algae alter the nature of soil and improve the moisture retaining capacity.

The liquid seaweed fertilizer obtained from seaweed extract is used as foliar spray for inducing faster growth and yield in leafy and fleshy vegetables, fruits, orchards and horticultural plants. There are several medicinal properties of seaweeds. Marine algae were considered to be of medicinal value in the Orient as early as 3000 B.C. The Chinese and Japanese used them in the treatment of goitre and other glandular diseases. Though the Romans believed seaweeds to be useless, they also used them to heal wounds, burns, scurvy and rashes. The British used ***Porphyra*** to prevent scurvy during long voyages.

The various red algae particularly ***Corallina officinalis, C.rubens*** and ***Alsidium helminthocorton*** were employed as vermifuges in ancient times. Dulse is a laxative and also used to reduce fever. Several red algae such as ***Chondrus crispus, Gracilaria, Gelidium, Pterocladia*** have been used to treat various stomach and intestinal disorders. The stipes of ***Laminaria cloustoni*** have been used to aid in child birth by distending the uterus during labour. A number of marine algae have been found to have anticoagulant and antibiotic properties. Carrageenan is used in ulceer therapy and alginates are found to prolong the rate of activity of certain drugs. Species of ***Sargassum*** were used for cooling and blood cleaning effect. ***Hypnea musciformis*** was employed as vermifuge or worm expelling agent and ***Centroceras clavulatum*** as cathartic agent. The iodine rich seaweeds such as ***Asparagopsis taxiformis*** and ***Sarconema furcellatum*** can be used for controlling goitre disease caused by the enlargement of thyroid gland. Many bio-active compounds can also be obtained from seaweeds. The fuel gas for domestic use can be produced from the brown alga ***Sargassum.***

The red algae ***Geldiella acerosa, Gracilaria edulis, G.follifera*** and ***G.crassa*** and brown algae ***Sargassum*** spp ***Turbinaria*** spp and ***Cystoseira trinodis*** are exploited at present from Mandapam coast and they are used as raw material by Indian seaweed industries for the production of agar, alginates and liquid seaweed fertilizer. The seaweed resources of Mandapam area should also be made use for the production of other phytochemicals such as carrageenan, seaweed food products like jam, jelly, pickle and wafer and feed for farm animals.

Seagrasses

In the world 13 genera and 52 species of seagrasses are distributed. In India 6 genera and 14 species of seagrasses are distributed in different regions of east coast, west coast, Lakshadweep and Andaman-Nicobar Islands. They are ***Enhalus acroides, Halophila beccarii, H.decipiens, H.ovalis, H.ovalis f.subsp. ramamurthiana, H.ovata, Thalassia hemprichii*** (Hydrocharitaceae), ***Cymodocea rotundata, C.serrulata, Halodule pinifolia, H.uninervis, H.wrightii*** and ***Syringodium isoetifolium*** (Potomogetonaceae). In Gulf of Mannar and Palk Bay regions of Mandapam except ***Halophila ovalis f.subsp. remamurthiana,*** all other 13 species are growing.

Seagrass beds are highly productive and form a dynamic eco-system. Seagrasses serve as sediment traps apart from stabilising the bottom sediments thereby improving the water quality. They are also involved in cycling of nutrients of their environment. They provide food and shelter for diverse organisms. In tropical waters parrot fishes ***(Sparidae)*** and surgeon fishes ***(Acanthuridae),*** dugong and green turtles are the main consumers and in the temperate waters mainly waterfowl geese and ducks graze the intertidal seagrass beds. In Gulf of Mannar and Palk Bay region ***Halothurian*** inhabitat the seagrass beds and ***Halodule and Cymodocea*** beds form a major browsing grounds for dugongs. Apart from being an important nursery ground for

commercially important fishes, seagrass beds harbour many species of crustaceans, molluscs, gastropods, worms and echinoderms. Seagrasses provide rich habitat for the macro and micro-algae as epiphytes

Uses of seagrasses

Some of the seagrasses such as ***Halophila ovalis*** are used as medicine to treat various skin diseases, burns, and boils. Unripe fruits of ***Enhalus acoroides*** are eaten and used for preparing salads. The rhizome of ***Cymodocea*** called "Kadal Karumbu" are also eaten by the local people. Fresh leaves of various seagrasses are used as green manure for coconut plantation.

Conclusion

Any damage to seaweeds and seagrasses habitats would result in their destruction. Increasing anthropagenic pressure on these marine habitats will definitely pose a serious threat to their very existence. Hence remedial measures are urgently needed to protect and conserve these important ecosystems and their resources for posterity and sustainable uses. Management plans are very essential to conserve the seaweeds and searasses which are facing threats by various factors. The Government should also pay much attention to the vital seaweeds and seagrasses ecosystems which in turn will promote the fishery potential of India.

Fish and Fisheries of Gulf of Mannar

A. Raju

Regional Centre of Central Marine Fisheries Research Institute,
Marine Fisheries- 623 520, Ramanathapuram District, Tamilnadu.

Introduction

India has an extensive coastline length of 7150 km. The Gulf of Mannar region occupies the southeast coast of India (Latitude - 8° 55' - 9° 15' N Longitude - 78° - 79° 16'E). The entire coastline of Gulf of Mannar from Thoothukudi to Dhanuskodi is sheltered from the fury of wind and waves by the existence of a chain of islands or sand cays. The Island system and coral reefs spread over this region offer shelter for a variety of marine fauna and flora. Both mechanised trawlers and non-mechanised vessels carry out the fishing throughout the year. But the shore seine fishing is seasonal in certain areas particularly in the southern region. When the Gulf of Mannar covering its southern portion becomes rough during April to September, the shore seine operations shift to Palk Bay and when the Palk Bay become rough during October-March, the units migrate to Gulf of Mannar. There are eight trawl fish landing centres such as Pamban (Therkuvadi), Mandapam (boat building yard side), Kilakarai, Ervadi, Valinokkam, Mundal, Vembar and Thoothukudi.

Infrastructure facilities

The infrastructure facilities along the Gulf of Mannar coast include boat building yard, fishing jetty, ice, fish meal and processing plants and dry docks. There are three fishing jetties each at Mandapam, Kilakarai and Valinokkam. At Thoothukudi, one minor small jetty and a major fisheries harbour are available. The cargo boats are berthed in the minor jetty and all the fishing boats are berthed in the fisheries harbour at Thoothukudi. The ice plants are available at Pamban, Mandapam, Kilakarai, Ervadi and Thoothukudi. Except Mandapam and Thoothukudi, there is no fish processing plant in between. The Mandapam jetty with a breakwater in the Gulf of Mannar side is a well-developed one in all weather conditions. It can accommodate larger vessels and provide shelter for small trawlers during heavy winds. About 50 vessels can be berthed at a time.

Fishery resources

Pelagic fisheries

Several species of fish inhabiting the pelagic zone contribute to the fishery in the Gulf of Mannar. The major groups are sardines, anchovies, mackerel, carangids, tunas and seerfishes. Majority of them are caught by gillnet, drift gillnets, drift nets and hook and line. The anchovies are caught both by trawlnet and shore seine. The dominant species are ***Sardinella albella*** and ***S. gibbosa*** among lesser sardines and ***Stolephorus commersoni*** and ***S. indicus*** in anchovies. ***Ethynnus affinis*** is a common species in tunas. The oil sardine ***S. longiceps*** is a seasonal fishery caught by pair trawl from Rameswaram and Pamban. Apart from this, the rainbow sardine ***Dussumiera*** spp. ***Hilsa*** spp. and ***Chirocentrus*** spp. are occasionally caught and form the minor pelagic fishery. The shark is an another important pelagic resource in the Gulf of Mannar.

Demersal fisheries

The major demersal fish groups consist of silverbellies, rays, perches, goatfishes, sciaenids and barracudas. Besides, groupers, catfishes, flatfishes and sandwhitings are also caught in appreciable quantities. The silverbelly is the most dominant demersal fishery resource

around Mandapam Region, which is used in fishmeal industry. They exhibit a diurnal migration resulting in large catches during day time and full moon periods.

There are about thirteen species of silverbellies contributed in the fishery in which ***Leiognathus dussumieri*** is the dominant one. ***Himantura*** spp, ***Dasyatis*** spp. and ***Gymnura*** spp. are the common species among the rays. The major perches are ***Lethrinus*** spp., ***Lutjanus*** spp. and ***Psammoperca*** spp. These are caught by gillnets, Hook and Line and occasionally in traps around the islands. ***Cynoglossus macrolepidotus, C. bilineatus*** and ***C. punticeps*** are the major species in flatfish. Among the goatfish, ***Upeneus sundicus, U. sulphureus*** and ***U. tragula*** in trawl and ***U. oligospilus*** and ***Parupeneus indicus*** in shore seines are common in Gulf of Mannar.

One of the traditional indigenous gear fishing in Gulf of Mannar is the 'Stakenet' locally called as *'Kalam Katti valai'*. It is operated throughout the year in the intertidal areas in the islands around Mandapam and Thoothukudi taking advantages of the tides and lunar phases. The fishes, which entangle in the net during high tides, are harvested in the receding tide. The duration of operation varies from 5-6 hours depending upon the starting of raising and receding tide. The dominant fish groups caught in this gear are the grey mullets (***Liza macrolepis; Valamugil seheli*** and ***Mugil cephalus***), followed by sandwhitings (***Sillago sihama***), silver biddies (***Gerres*** spp.), ***Elops*** spp., the milkfish (***Chanos chanos***), ***Rhynchoramphus*** spp, ***Belone*** spp., ***Tachysurus*** spp., ***Lactarius*** spp. and crabs.

Crustacean fisheries

The crustacean fishery resources of this region include shrimps, crabs and lobsters. About 95% of the shrimp resources comprise of penaeid prawns. Pamban and Mandapam based trawlers fish off Ervadi and trawlers from Kilakarai, Ervadi, Valinokkam, Mundal fish prawns in the area between off Ervadi and off Vembar. The trawlers have limited approach in the Gulf of Mannar stock, as the fishing grounds are deep when compared to Palk Bay. But along the southern flank trawling is done both by mechanised and non-mechanised vessels. The area between the chain of islands and mainland is trawled by non-mechanised boats taking advantage of the wind force and direction particularly during northeast monsoon. But good catches are obtained from the open sea beyond the islands.

The major species contributing in the prawn fishery are ***Penaeus semisulcatus, Parapenaeopsis maxillipedo, P. coramandelica, P. uncta, Trachypenaeus pescadorensis*** and ***Metapenaeus burkenrodi.*** The dominant contribution in the fishery is by ***P. semisulcatus***. The juveniles of ***P. semisulcatus*** form the main fishery in thalluvalai. The dominant species that form in crab fishery is ***Portunus pelagicus***. They are caught in trawl and non-mechanised vessels. In trawlers, ***P. pelagicus*** form by-catch and ***Scylla serrata*** form part of fishery in non-mechanised vessels. The other two species of crab ***P. sanguinolentus*** and ***Charybdis cruciata*** sporadically occur in the catch. Prawns are readily purchased by the agents of the processing companies right on the beach and taken to the factories in insulated vans. They are exported to European and Gulf countries, U.S.A. and Japan.

Molluscan fisheries

The molluscan fishery resource consists of cuttlefish, squids, chanks, pearl and edible oysters and clams. In cuttlefish, ***Sepia aculeata, S. inermis, S. pharaonis*** and ***S. breveimana*** are the major species. ***Sepioteuthis lessoniana*** and ***Loligo duvaucelli*** are common squids available in Gulf of Mannar. Both cuttlefish and squid are export commodities. Cuttlefishes are cleaned and their viscera, cuttle bones and tentacles are removed. The white fleshy portion of the body is deep freezed and exported. The edible oyster

Crossostrea madrasensis, the great clam ***Meretrix meretrix*** and blood clam ***Anadora granosa*** are commonly occurring at Thoothukudi.

The Gulf of Mannar is of very great importance for pearl and chank fisheries. The submarine plateau of the inshore areas affords excellent habitat for the growth of pearl oyster ***Pinctada fucata*** and the sacred chank ***Xancus pyrum***. Chanks prefer fine and soft sandy areas locally called 'Poochimanal' or 'piral' and the oysters are attached to hard rocky substrata called 'paar'. There are more than 65 well-known 'paars' and lesser in number of good chank grounds in the Gulf of Mannar known to fishermen by their depth and location fixed by land bearings.

The pearl oysters and chanks are fished by the age-old skin diving by expert fishermen. The craft and accessories used for fishing both chanks and pearl oysters are identical. Fishing by skin diving is possible only in clear waters and the season depends on the locality. The chank fishing is done at Vedalai, Periapattinam, Kilakarai, Mundal, Kannirajapuram and Thoothukudi when the Gulf of Mannar is calm and the waters clear from November to middle of May. The oyster fishing is done only at Thoothukudi.

Other fishery resources

The holothurians commonly known as sea cucumbers are one of the commercially important marine resources and are exploited on a large scale along the Gulf of Mannar region. The holothurians, locally called 'Atta' are boiled and sundried after repeated processing side Beche-de-mer, the dried product of this animal is exported to Indonesia, China and Singapore which form one of delicacy in the food items in these countries. The intertidal areas of the islands in the Gulf of Mannar are rich in holothurians such as ***Holothuria scabra*** and ***H. atra***. They support a well-established Beche-de-mer industry in India.

The Gulf of Mannar is also a grazing ground for the sea cow Dugong dugon. The ***Cymodocea*** beds (seagrass) offer a good grazing ground for the dugongs. Dolphins, another marine mammal also occur in the Gulf of Mannar sea. Though these are protected animals under Indian Wild Life Protection Act, 1972, they are hunted indiscriminately for their flesh.

Another unique feature of island ecosystem in the Gulf of Mannar is the cultivable fin and shellfish seed resources. The tidal streams and tidal creeks in the islands as well as in the coastal region at Pamban offer vast potential grounds for the collection of seeds. Seed of milkfish (***Chanos chanos***), grey mullets (***L. macrolepis*** and ***L. seheli***), the sandwhiting ***Sillago sihama***, the rabbitfish (***Siganus*** spp) and the prawn (***P. indicus***) are occurring in Krusadai, Pullivasal, Poomarichan, Manoli, Manoli-puti and Hare islands and also at Chinnapalam and Thoppukadu of Pamban. Milkfish fry and fingerlings can be collected from March-July and mullets throughout the year.

In recent years, the ornamental fishes have assumed importance due to its great market potential. They are caught and exported to foreign countries. A wide variety of these fishes occur in Gulf of Mannar. The coral reef beds provide shelter for these fishes. To mention some of the ornamental fishes are ***Amphiprion sebae, Monodactylus argenteus, Holocentrus rubrum, Chaetodon collaris, Abudefduf septemfaciatus, Callyodon ghobban, Pterois volitans, Cephalopholis boenak, Lutjanus*** spp. ***Scatophagus argus, Acanthurus*** spp. ***Lethrinus*** spp. ***Hippocampus*** spp. and ***Syngnathus*** spp.

Conclusion

Nature conservation of marine resources and habitats has assumed great significance in the context of the role of conservation in socio-economic development and the execution of its functional role. The Central Marine Fisheries Research Institute with its centres at Mandapam and Thoothukudi has conducted a detailed survey of all the islands in the Gulf of Mannar extending from Rameswaram to Thoothukudi for the establishment of marine park. Due to the rich faunal and floral assemblage, the Gulf of Mannar Biosphere has been declared as 'National Marine Park'.

Fishing Methods of Gulf of Mannar

V .Gandhi
Regional Centre of Central Marine Fisheries Research Institute,
Marine Fisheries- 623 520, Ramanathapuram District, Tamilnadu.

In order to present recent information regarding the fishing method of Gulf of Mannar, this article has been written. Different types of crafts and gears have been described. Recently motorisation of indigenous craft has been introduced. Most of the nets have been fabricated by synthetic or nylon threads. Informations regarding the size of the craft, material used for the construction of boat, horse power and the trade mark of diesel engine, length, width and mesh size of the net are presented. Fin fishes and shellfishes which are caught in this region are also given.

Crafts in operation

Plank built mechanical vessels named IB and STB are operated in the zones-13, 13A and B and 14, which are situated in the Gulf of Mannar. There is no change in the size of boat or the material, which is used for the construction of boats from the period of introduction of mechanised vessels to this region. Wooden frames and planks are used for the construction of the vessels. The length of the STB boat is 10.8 to 12.6 metres and width is 3.5 to 4.5 metres. Most of this type of vessels are fitted with Ashok Leyland disesl engines with a HP of 88 to 108. These boats are operated at a distance of 10 to 30 km from the shore. The depth of operation is 14 to 36 metres. Required manpower for the operation of this vessel is 5 to 6 persons. The other one is called IB boat. The material used for the construction is wooden frames and planks. Generally the length of the boat is 0.92 to 12.0 metres with a width of 3.5 to 4.5 metres. Here also Ashok Leyland diesel engine with a horse power of 50 to 120 is fitted in the vessel. Required man power is 5 to 6 persons. Depth and distance of operation are 14 to 36 metres and 10 to 30 km respectively. There is no change in the size and in the constructing material.

Mechanised plank built country craft

These are plank built country crafts previously used without engine. Nowadays these crafts are fitted with in-built Kirloskar diesel engines with horse power of 12 to 18. The length of the boat locally called vallam/Tuticorin type of vallam is 28 to 32 feet. The boat is made of wooden frames and planks. There is no change in the size or in the length. But only introduction is the fitting of in-built diesel engine. Manpower is 5 to 8 persons.

Plank built country craft (Vathai)

These are made of wooden frames and planks without in-built diesel engines. Length of the boat is 18 to 25 feet. This is the traditional type, which is operated for a long time. There is no change in the length and in the size. Required man power is 1 to 6 persons. These boats are locally called vathai or vallam.

Plank built boat for the operation of shore seine (Thoni)

These are constructed by the use of wooden frames and planks. Length of the boat is 30 to 36 feet. Man power is 25 to 30 persons. There is no change in the size and in the length over the years.

Kattamaran

Locally called Kattumaram is made of 3 to 4 number of wooden logs tied together to form an unit.

Required man power is 3 to 5. Lengths of each piece of wooden log is 12 to 30 feet. This is also traditional one, which is used for over the years.

Gears in operation

Trawl net

These nets are made of nylon threads or synthetic fibre. The length of the net is 16 to 21 metres. The mesh size in the cod end is 15 to 20 mm. The weight of the otter board is 38 to 55 kg. These are operated generally at a depth of 10 to 25 metres. Two to three hours is taken for a haul. The catch will be unloaded with the help of man power or by the use of power winches. For the catch of fish, the net will be operated above the bottom whereas for the catch of shrimps, it will be operated at the bottom only. This type of operation is only carried out since that time of introduction of this net. Till date there is no change in the operation.

Gill nets in operation

So many varieties of gill nets with different lengths, different widths and different mesh sizes are operated in this region. Bottom set gill nets locally called Nanduvalai, Singieralvalai, Discovalai, Thirukkaivalai and Kattavalai are made of plastic or nylon threads. Length of the each piece of net is 100 to 200 metres and width of the net is 2 to 12 metres. Mesh size ranges from 11 to 39 cm. Synthetic or aluminium or cork floats are used. Small piece of stones or small wheel shaped cement blocks are used as sinkers. Drift gill nets locally called Paruvali, Kottuvalai, Valivalai and Thangoosivalai are made of nylon threads. The length and the width of each piece of net are 30 to 200 metres and 6 to 10 metres respectively. Mesh size is 2.7 to 17 cm. Aluminium or synthetic or wooden floats are used. Small piece of stone sinkers are used. Gill nets locally called Choodavalai, Peruvalai, Muralvalai, Kalankattivalai, Mayavalai and Koivalai are made of nylon threads. Length and width of each piece of net are 24 to 200 metres and 2 to 8 metres respectively with a mesh size range of 1 to 7 cm. Synthetic or metal or aluminium float and aluminium or stone sinkers are used.

Hooks and lines locally called Ayirankal thoondil consists of long and small size of nylon ropes, branch line of monofilament-threads, 40 numbers of hooks and aluminium sinkers. The length of the line is 1000 metres, whereas the hand line which is also called thoondil consists of main and branch line of monofilament threads and 40 number of hooks. The length of the line is 20 to 25 metres. Disco thoondil has a length of 20-25 metres of monofilament threads and 40 numbers of hooks.

Traps are made of splits of branch of Acacia tree or bamboo reapers or palmyrah leaf. The length and width of the trap are 37.5 to 62.5 cm and 42.5 to 43.8 cm respectively. The diameter of the mouth of the trap is 11.5 to 15 cm and the mesh size is 1 to 9 cm.

There are two types of shore seines locally called olavalai and karavalai are operated in this region. Olavalai is made of nylon threads and consists of scare line of 1000 metres (coir rope attached with palmyrah leaf), wing portion of 7 metres, coir ropes of 100 metres and aluminium floats. The mesh size of the cod end is 1.5 cm. Karavalai is made of nylon threads. The unit consists of bag portions of 10 metres, wing portion of 39 metres cotton and 480 metres of hemp threads, wrap of 900 metres, synthetic or aluminium float and aluminium sinker. The mesh size of cod end is 1 to 5 cm.

Fish catch

Fish and shellfish commonly caught by the above mentioned gears are ***Penaeus semisulcatus, Metapenaeus affinis, Upeneus*** spp. ***Otolithes*** spp., ***Gerres*** spp. ***Sillago*** spp. ***Leiognathus*** spp. ***Portunus pelagicus*** spp. ***Lactarius lactarius, Himantura*** spp. ***Caranx*** spp. ***Parupeneus spp. Loligo*** spp. ***Polynemus*** spp. ***Panulirus homarus, Panulirus*** spp. ***Xancus pyrum, Sardinella*** spp. ***Dussumiera*** spp. ***Ilisha*** spp. ***Penaeus indicus, Valamugil seheli,***

Lethrinus spp. *Epinephelus* spp. *Chirocentrus* spp. *Sphyraena* spp. *Scombromorus* spp. *Rastrelliger kanagurta, Hemirhampus* spp. *Strongylurus* spp. *Exocoetus* spp. *Siganus* spp. *Psammoperca waigiensis, Sepia* spp. *Johnius* spp. *Nemipterus* spp. *Drepane* spp. *Therapon* spp. *Cybium commerson, Pellona ditchella, Scylla serrata, Pennahia* spp. *Sphyraena* spp. *Arius* spp. *Istiophorus* spp. *Coryphaena hippurus, Callyodon* spp., *Lutjanus johni, etc.*

Generally fish catch in the Gulf of Mannar is going on-decreasing because ofoverfishing. Eventhough the indigenous crafts with in-board diesel engines with nylon gears are operated, the fish catch is not a satisfactory one. To improve the catch of fish modern techniques in fishing should be followed traditional fishermen also.

Shell Industries of Rameswaram Islands

I.Jegadis
Regional Centre of Central Marine Fisheries Research Institute,
Marine Fisheries - 623 520. Ramanathapuram District, Tamilnadu.

Introduction

Seashore has always been a fascinating and recreational place for young and old. In every seashore, people of diverse age groups can be seen moving around and picking things. What is that they are looking for and collecting! Yes, it is nothing but the 'SHELLS'. Shells are the hard calcareous part, literally the 'HOUSE' of the soft bodied living animals called molluses. When the animal dies in course of time, the shells are washed ashore and strewned around in the beach.

From time immemorial, people were collecting the shells and used it for different purposes as per their requirement like ornaments, vessels and weapons. Ancient tribes used Conch and Triton shells as trumpets to summon people.

The importance of these shells have become evident only a couple of decades back when the shell products and shells paved their way in to the drawing rooms of the modern world. Daily use items ranging from key chains to wall clock were made out of or with shells. This encouraged shell collecting into a small scale industry and within no time it developed into a full fledged and worldwide industry.

Ramanathapuram District

Ramanathapuram is a backward district with limited industrial development. The only flourishing industry is fishing. Ramanathapuram coast is dotted with more than 75 fishing villages from Sundarapandian pattinam (Palk Bay) in the north down to Rochma nagar (Gulf of Mannar) in the south. Of these landing centres many are valuable shell collecting centres. Shell industry as such has taken to shape only in Kilakarai and Rameswaram. being a major tourist centre and almost throughout the year it is visited by local and foreign tourists. The business slowly picked up and hardly 10-15 years back the industry has become a major one at this centre.

Shell resources

No variety of shells are discarded as useless when the shell industry is concerned. The very small horn shells (***Cerithidea*** spp) to the giant clams (***Tridacna*** spp) are considered as resources. The industry is dependent on the seashells of different variety which are collected from the sea mainly by engaging divers. The raw materials are mostly live shells. After collection, they are accumulated and transported to this centre from almost all the fishing villages in both the coasts of the country. To enhance the speedy supply of a particular shell variety, which is in great demand, the industry people advance money to the divers and get the materials supplied. Womenfolk's from the fishing community are also involved in the collection of seashells that are available in the near shore. Apart from these there are also whole sale purchasers and suppliers of seashells who collects and forward varieties of sea shells to the shell industries throughout the India.

Size of Industry

In Rameswaram, shell industries ranged from tiny retail outlets to major industries. In all about 10-15 major shell industries, which runs business in terms of multiples of lakhs of rupees. Apart from these another 15-20 minor sized shell industries also exist. In general, a major industry at Rameswaram is engaging about 25-30 people mostly men for cleaning and polishing alone in the sheds apart from other workers involved in different works.

Methods of product development

The beauty and the value of the shells depend largely on the way it is cleaned, processed and decorated. Most amateurs still uses the crude method to clean the seashells and by that the natural beauty is lost and become unattractive. There are few methods of shell cleaning:

Burying method

The shells with flesh are generally buried in soft, dry sand in which condition the soft parts of the animals gets decomposed by microbes in the soil. Later the shells are collected and cleaned with the jet of water and subsequently in warm soap water. This type of cleaning is suitable when the shells are not in immediate requirement for product development.

Hanging method

This method is adopted for medium and big sized gastropods. The foot of the animals is strung by a rope and hung. Due to the shell weight entire animal is pulled out of the shell within a day or two. Later the shells are cleaned and used.

Open air drying method

Shells are placed outside on the ground after removing the operculum. The shell should be placed in such way that its meat portion is shaded from direct sunlight. Flies lay their eggs inside and later hatch out as maggots which in turn eats the soft body and thus the shell got cleaned.

Boiling method

Care has to be taken in this method of shell cleaning where the length of boiling in relation to the size of the shell is critical. Longer boiling makes the shell appear dull in colour and beauty. Shells, which are very glossy, should not be directly put in the boiling water. Gradual raising of water temperature to boiling point and remaining there for the required time and allowed to cool slowly. Sudden cooling will result in the cracking of the shell surface. The soft parts are removed by needle and the encrustations on the shells with blunt scalpel. The remaining flesh part inside the shells can be removed by immersing the shell in 2-5% caustic soda for a period of 12 hours.

Cleaning methods adopted in commercial sheds of Rameswaram

Cleaning of shells in a cost effective way is adopted in most of the commercial sheds. Shells of different varieties, shape and size were stacked in open and allowed to decay. They are kept in small cemented tanks with full of water, which facilitates decaying of the soft flesh. The water along with the decayed flesh is drained out and fresh water is added periodically. The shells are washed and rinsed individually and the encrustations are removed by a scalpel. Such shells are then washed in hot water with small quantity of Hydrochloric acid added to. Thus the cleaned shells become glossy.

Caustic soda and lye (mixture of sodium hydroxide and sodium carbonate) are also used to remove the calcareous castings on the shells. Normally one litre of lye will be dissolved in two litres of water and allowed to cool for 24 hours. The shells are kept immersed for 12 hours and subsequently the calcareous castings are removed. Strong Hydrochloric acid is also used for cleaning but only by experience this is possible. The shells are finely polished, beautified and defects like pores and cracks if any are masked by applying wax.

Shell products

Shell products are of two different categories i.e. finished whole shells and shell crafts.

Finished whole shells

Whole shells of different species like Five finger shell (***Lambis*** sp), ear shells (***Haliotis*** sp) beggar's bowl (***Cymbium*** sp), ***Pinna*** sp and ***Strombus*** sp, are liked by people purchased and kept as show pieces in the houses. Some of the

shells like sacred chank (*Xancus* spp.) particularly the sinistral type is considered as religious symbol and keeping them in the houses is believed to would bring prosperity. Big sized polished shells are now popular and occupy a special place in Restaurants, Hotels, and places of gathering. Shells of small sized cowries are used as play tools for the kids and bigger sized shells of cowries and conus are for making key chains, as paper weight with engravings on the top. Full sized top shells (*Trochus* sp.) and turban shells (*Turbo* spp.) are used for making night lamps.

Shell crafts

The skill of making ornament and other useful items out of polished shells either whole or sized to requirement is called shell craft. It may be too difficult to date back when exactly this art started. However, even the tribals of many of the backward area of this continent are found wearing ornaments made of crudely polished/unpolished shells with certain degree of creativity. When civilisation advanced the major industry that was originated from the shell is the bangle industry in West Bengal. Shell bangles of West Bengal made out of chanks are cutely carved and variety of designs embedded are world famous. Shell bangles are also a mark of married women.

Modern world has made use of all kinds of shells and produces variety of items ranging from key chains to wall clock and small chandeliers for household uses. Whole shells of *Babylonia* sp are stringed together to make wall hangings and door hangings. Polished whole shells of different sized shells are used in the making of decorated wall clocks and mirrors. Decorative, show pieces and ornaments like ear rings, rings, bracelet, pendant etc are made out of whole, cut and carved shells of many varieties with lustrous shining such as *Trochus, Turbo, Pinctada* are now ruling the market among the fashion lovers.

Export potential

Indian shell crafts are widely acclaimed in many of the western countries. The most important of the export market to India is United States. Even though no export is now being done from Rameswaram centre there are many major shell industries established at Chennai and Mumbai is export oriented. As on today, the shell industry at Rameswaram is confined to the local demands within the country but has the potential to grow to the size of a leading export industry in India in no time.

Government taxing on shell industry

Currently, the Government is levying a tax rate of 8-16% on the various items of shell products. However, full exemption of tax is given when the whole shell is polished and marketed.

The industry people are of the view that if any reduction in the present taxing rate is given it could enhance the net profit margin for them which is 5% now.

Employment generation

Shell industry is a sort of network activity, which involves many persons right from shell collectors, whole sale buyers and suppliers artisans engaged in the shellcrafts. Womenfolks are involved in both collection and also in product development. The women collects the cleaned and polished shells from the industry and completes the job of decorating fancy and household items and returns the finished product from their home itself. They were paid either daily or per piece of work as the case may be. Retailers are the other set of people who are benefited by the industry. As a whole, a major shell industry sustains the lively hood of about 500-750 persons.

Mangrove Ecosystems of Gulf of Mannar, Tamil Nadu

Dr. P. Nammalwar* and Dr. K.Muniyandi
Regional Centre of Central Marine Fisheries Research Institute,
Marine Fisheries - 623 520. Ramanathapuram District, Tamilnadu.

Introduction

Mangroves are termed as 'Tropical tidal wet lands' with typical vegetations distributed along the border of the sea and lagoons reaching upto the edges of the rivers to the point where the water is saline and growing in swampy soils covered by the saline water durng high tides. The mangroves dominate almost one quarter of world's tropical coastline. When conditions are favourable, they may form extensive and productive forests protecting the coastline. Mangrove ecosystem serves as the reservoir of species of plants and animals associated together. The mangrove swamps and forests are more diverse and luxuriant in the Indo-Pacific region. The mangroves of India have received inadequate and insufficient attention in the past. Most of the mangroves are on the verge of disappearance due to over-exploitation. No sustainable effort has been made to study them in a comprehensive manner.

There has been increasing awareness among the scientific community that the mangrove biotope is an important component of the tropical ecosystem. The role of mangroves in nature and their ecological significance have been realised of late and the Government, scientific Institutions and Universities are paying increasing attention to the biology, conservation and management of mangrove areas. Apart from the economic uses of its resources, the mangroves are potential grounds for coastal aquaculture. It is generally recognised that mangrove areas form the breeding and nursery grounds for the larvae and juveniles of many commercially important species of prawns and fishes. The high productivity resulting from mangrove litterfall supports a host of detritus feeding animals such as amphipods, mysids, harpacticoids, molluscs, crabs and larvae of prawns and fishes. The mangrove vegetation and associated creeks and channels provide habitats to these organisms especially in their critical stages of life-history. The role of the mangrove forests in stabilizing the shoreline or coastal bed is well known, The important role played by the mangrove forest and swamps in the production of detritus, dissolved organic matter and recycling of nutrients is being increasingly realised.

Districation of Indian mangroves

The world's total mangrove area which spans over 30 countries including those for the various island nations is about 1,00,000 sq. km. The total area of the Indian mangroves is estimated at 6,81,976 hectares of which nearly 45% occurs in Sunderbans and the islands in the Bay of Bengal. Other important mangroves are Killai and Pichavaram and Gulf of Mannar Islands in Tamil Nadu, state of Kerala, Karnataka, Gulf of Kutch and Andaman &

* **Present Address :** **Madras Research Centre of CMFRI,**
68/3, Greams Road, Chennai - 600 006.

Nicobar islands. The Andaman-Nicobar islands contain some of the least disturbed and best preserved mangroves. The Andaman-Nicobar islands have about 1,190 sq. km. area of mangroves. Here, the forests are gregarious type, dominated by single species. The Sunderbans formed in the vast delta complex of the Ganga and Brahmaputra river systems are usually described as the largest single natural mangrove block having an area of 4,170 sq. km. in W. Bengal. It is noteworthy that today, in Kerala, there is no dense mangrove forest in spite of its generally very heavy rainfall as compared to the other States of the west coast of India. It is contrary to the general rule that the maximum development of mangroves is in the regions with heavy rainfall. Tidal currents and freshwater supply influence the physico-chemical factors in the mangrove estuarine systems to govern the distribution and zonation of the mangrove species, of which temperature and salinity of the ecosystem appear to be important factors.

On the basis of the height of the vegetation, 3 categories of forest stratification can be observed in a normal mangrove ecosystem. The widest trunk with spreading crown is found in species of ***Sonneratia*** and ***Avicennia*** and less spreading crown found in the species of ***Bruguiera*** and ***Rhizophora*** which constitute the top canopy of the forest. The second category is contributed by shrubs and small trees represented by the species of ***Aegeceros, Exoecaria*** and ***Ceriops***. The third one is occupied by small shrubs and ferns such as species of ***Acanthus, Aegiolitis*** and ***Acrostichum.*** Globally, mangrove ecosystems are though to contain about sixty species of true mangrove trees and shrubs and more than twenty additional species frequently associated with the mangrove flora. They exhibit a remarkable capacity for salt tolerance and hence they are physiological halophytes. The leaves possess halophilous properties with thick cuticle, large mucilage cells etc. The formation of butress and stilt roots and vertical pneumatophores are characteristic adaptations. The composition of the mangrove species changes with depth, salinity, wave action, intertidal exposure etc. Diversity in the structural formation and zonation of mangrove forests can be witnessed along the latitudinal gradients and probably also along the longitudinal gradients that reflect climatic, especially rainfall gradients. Across the latitudinal gradients, air temperature and across the longitudinal gradients, water and soil fertility appear to be the most important factors in determining the growth patterns of the mangrove populations.

Influence of mangroves on flora and fauna assemblage

Mangrove systems are among the most productive natural ecosystems on earth. The sources of primary productivity are the mangrove vegetation themselves, algal colonies associated with the mangrove root surfaces and the moist forest floor and the phytoplankton communities in the associated bay and lagoons. Algae observed in the intertidal regions of mangroves are very rich and diverse in both quality and quantity. The benthic algae of the mud surface are represented by the green filamentous species of ***Enteromorpha, Rhizoclonium, Monostroma*** and ***Ulva.*** The mangrove environment provides living space for a dependent biota of more than two thousand species of flora and fauna of resident, semiresident or migratory mode of life. The mangrove associated fauna, being a composite of terrestrial, estuarine and marina organisms, constituting representatives of almost all invertebrate phyla and fishes have to face numerous interactions between animals of terrestrial and aquatic biotopes. As such, the mangrove fauna with its lower species diversity but with relatively large number of individuals is highly characteristic in nature. The primary food source for aquatic organisms in most mangrove dominated estuaries occurs in the

form of particulate organic matter (detritus) derived chiefly from the decomposition of mangrove litterfall. The annual litterfall normally ranges from 10,000 to 14,000 kg dry weight per hectare. An additional sources of nutrition is provided by dissolved organic compounds of mangrove origion. The predators feed on the detritus feeders and form important food source for both aquatic as well as terrestrial wild life in addition to forming food resource for human beings.

In general, the fauna of mangroves constitute insects, crustaceans, molluscs, fishes, snakes, crocodiles, birds, monkeys and some other mammals. Very few studies are made with respect to plant animal interactions. The mangrove waters are rich in detritus providing a highly potential area for fishing. The major fishery sources in these waters are detritus species of fishes, crustaceans and molluscs. It has been estimated that the yield of mangrove-cum-estuarine dependent fisheries of India to the tune of 30,000 tonnes of crustaceans per annum. Roughly about 60% of India's coastal marine fish species are dependent on the mangrove estuarine complex. Some of the most common fishes of mangroves are species of ***Liza, Mugil, Polynemus, Ilisha*** and ***Etroplus.*** Prawns are represented by the species of ***Penaeus*** and ***Metapenaeus*** while crab resource waters are species of ***Crassostrea, Meretrix, Telescopium*** and ***Cerethedia***. The major gears used for fishing are stake-nets, cast-nets and hand-picking in the mangrove areas.

There are 5 important factors that influence mangroves, namely, temperature, salinity, tides, rainfall and winds; each having its own effect. Temperature influence the development and survival of the mangroves in the early stages. Salinity determines the distribution and zonation of the species within the ecosystem since each species has got its salinity tolerance. Tides act jointly with salinity in the dispersion and zonation; and the tidal amplitude determines the landward extension of the mangroves. Rainfall is important in the zonation of mangroves on flat coasts and the productivity of the mangrove ecosystem is related to the frequency and volume of freshwater supply by rainfall. Wind is important in regulating the seasonality of litterfall which is the major pathway of energy from terrestrial, to aquatic system. Mangroves colonize on a variety of substrata that include silty and clayey mud, calcareous mud, quartz sand, calcareous sand or mixture of these. Occasionally they may colonize coastal coral reef as well as cracks and hollows of rocky substrata. They prefer sediments that have been brought by rainwater or transported by tidal currents. The mangrove soils are generally slightly acidic. The anaerobic condition in the soil helps sulphate reducing bacteria to produce Hydrogen sulphide. The characteristic black or grey colour of the soil is due to reduction of ferric compounds to ferrous sulphides.

In general, atmospheric mean temperature of most of the mangrove habitats in the Bay of Bengal varies from 29-33°C while surface soil temperature ranges from 30-34°C and surface water temperature from 28-33°C. Salinity of mangroves fluctuates considerably ranging from 3 to 33 ppt in landward and creek waters; and in the bay it varies from 25 to 35 ppt. The pH of the water fluctuates from 6.5 to 8.0 and dissolved oxygen content is usually very low ranging from 1.7 to 3.8 mg/l. However in the seaside, it may reach even 10 mg/l. The primary productivity of the mangrove waters is very high. Gopinathan and Rajagopalan have been reviewed the productivity of the Andaman-Nicobar mangroves. According to Nair and Gopinathan (1983), the primary productivity rate ranges from 0.2 to 0.8 g C/m^3 / day in the northern Andamans, slightly higher values from 0.5 to 1.0 g C/m^3 day in the shallow mud flats and mangroves of Car Nicobar and higher productivity rates from 2.0 to 3.6 g C/m^3/day in and around the mangroves of Port Blair. In recent years, the mangrove environment is getting polluted with

different kinds of effluents and other contaminants from the factories and industrial wastes. Heavy metals pose a serious problem due to their environmental persistence and toxicity to aquatic organisms even at a lower concentration. Hence, it is very important to monitor the Heavy metal pollution by taking suitable managerial measuresto protect the valuable mangrove resources. Increasing human pressure for domestic needs and development of industries are virutally destroyed large areas of virgin mangroves all over the world. Reclamation of mangroves for housing, agriculture and salt evaporation site, grazing of cattle, removal for fuel, sewage discharge with high BOD, discharge of industrial effluents and excessive release of pesticides and aquaculture practices have threatened most of the mangroves and some are in the verge of extinction. These degraded areas need to be restocked and fresh mud-flats need to be afforested with suitabie mangroves. Silvicultural techniques like regeneration, restoration and afforestation of mangrovescan be the only answer to these problems.

Like any other types of forests, mangroves from the national wealth of a nation. Timber produced from mangroves is of great value. Wood of ***Rhizophora*** is used for boat-building which is resistant to termites and boring animals. Mangrove trees are used as fuel wood or for charcoal. Mangroves were the main source of tannin industry once but now gradually replaced by synthetic tannin. A black dye is also extracted from the bark of mangrove trees. Seeds of ***Cerebra odlun*** is poisonous and fish poisons are extracted from it. Mangroves are good breeding and nursery grounds for a variety of prawns and fishes. It provides nutrition for various organisms through recycling of plant and animal remains. Of course, mangroves give protection to the coastline and minimise the disaster due to cyclones. Aquaculture practices in the mangrove sites of many countries are flourishing even now. Protection of bird sacntuaries and endangered species of wild life (crocodiles and tigers) are the other important aspects of mangroves. Mangrove ecosystems, with their variety of subhabitats, offer range of recreational opportunities such as boating, hunting, bird watching, wild life observation, education trips for specimen collections, photography etc. A part from these, fishery activities (culture and capture) in many coastal regions of the tropics are highly dependent upon mangrove dominated estuaries. Aquaculture in mangroves signifies a case of necessity rather than suitability. In specific cases of aquaculture in the mangrove ecosystem economic and social benefits may outweight management problems. A major part of the primary production enters the mangrove food-web a dead organic ecosystem or transported into the adjoining water body in a degraded form and the estuaries and backwaters fringed by mangroves have long been used for rearing or fattening of bivalves, prawns and finfishes.

Mangrove ecosystems of Gulf of Manner, Tamil Nadu

A survey on the distribution of various species of mangroves in Shingle, Krushadi, Poomarichan, Manoli-putti, Manoli, Hare, Muli, Poovarasanpatti, Anaipar, Upputhannai, Kasuwar, Valai, Appa, Nallathanni, Karaichalli, Vantivu, Talayari, Valimunai, Puluvinichalli, Vilanguchalli and Rameshwaram islands of Gulf of Mannar was conducted during January, 1995 - December, 1997. The various species of mangroves such as ***Avicennia marina, Rhizophora mucronata, Brugeiera cylindrica, Ceriops decandrus, Luminitzera racemosa, Exoecaria agallocha*** and ***Suaeda*** spp., are distributed in these selected islands surveyed. It may be revealed that Krushdai, Manoli and Poomarichan islands are found to be more productive in mangrove vegetation when compared to other islands of Gulf of Mannar. Survey on fish and prawn seed resources was undertaken in the mangrove

areas of selected islands of Gulf Mannar such as Krusadai, Hare and Poomarichan islands and Rameshwaram (Pamban) to find out the influence of mangroves on fish and prawn seed abundance. Simultaneously, survey on fish and prawn seed resources in the non-mangrove areas i.e., marine habitat of the above islands was carried out for comparative studies.

Conservation and management

In India, mangroves are under pressure due to increasing population, development of ports, salt pan and aquaculture, dumping of industrial wastes and effluents, development of fertilizer plants and exploitation for petrochemical activities. Conversion of mangrove area for aquaculture and residential purposes is also leading to loss of this important ecosystem. Based on the above observations, a concerted and co-ordinated effort is necessary to undertake management measures to conserve these natural resources. With a view to preventing further destruction of mangrove forest, it is felt that an integrated approach is required. The conservation of the existing mangrove resources is the first step towards achieving this goal.

The art of keeping marine aquarium

Boby Ignatius
Regional Centre of Central Marine Fisheries Research Institute,
Marine Fisheries - 623 520, Ramanathapuram District, Tamil Nadu.

Bringing a small section of the marine environment to your home sounds like a difficult task. But it is being done by more and more by the average aquarist, who wants to try this difficult task. Tremendous progress has been made in the keeping of the marine fish over the past decade. Much knowledge has been acquired and many new products have entered market to facilitate the keeping of marine fish. In many ways, a freshwater aquarium and a marine aquarium, are very similar. But the care required by a marine aquarium is more complicated than that demanded by freshwater tank. Pollution and diseases are likely to occur much more quickly and lethally in a marine aquarium than in a freshwater aquarium. Because of these reasons, a successful freshwater aquarist sometime find it difficult to keep a marine aquarium.

The procedure described for starting a marine aquarium is one that has been used successfully in the institute's marine aquarium facility and also by many successful individual aquarists. There are many additions and modifications may be made to the ecosystem recommended; however use of biological filter is a must for a successful marine aquarium keeping.

Aquarium tank

Choosing correct size, shape and its construction is important for a successful aquarium keeping. Marine aquarium tanks should have a size of more than of 100 litres. Small tanks are vulnerable to overcrowding very easily. Tanks should be constructed entirely of glass. Tanks with metal frames are unsuitable because the frame will rust and life of the tank will be shortened. All glass tanks consist of five pieces of glass and are held together with a silicon sealant. Low height tanks with more surface area is more preferable than high tanks with less surface area. For a marine aquarium, lid to cover the top of the tank is needed. This will reduce the evaporation from the tank which eventually increases the salinity of the water. Also in this lid we can fix the lights to illuminate tanks.

Location

Do not set up the aquarium in front of a window in direct sunlight or heavy growth of algae will occur. The room should be of nearly constant temperature. It should also be a room frequented by people otherwise the fish will develop a sensitivity to any movement outside the tank and will hide when you come nearer. Tanks should be placed in a perfectly levelled stand with thermocole sheet spread over it inorder to give a cousioning effect to the tanks. Also the stand should be strong enough to hold the tank with water, sand, and other accessories.

Water

The life of an animal is largely dependent on the quality of the environment in which it lives. Collect seawater from the offshore area having good tidal flushing and no pollution. Before using freshly collected seawater store it in a dark place for 2 - 3 weeks. Remove water carefully so that sediments are not disturbed. Also filter the seawater before use, in order to remove plankton, particulate matter and small parasites.

Filtration

Harmful and potentially harmful substances may gradually accumulate in aquarium water, eventually poison the animals. Only filteration can keep this from happening. A successful aquarist uses three filteration processes like, biological, mechanical and chemical, among which the first is very important.

Biological filteration

A good biological filter is the heart of a successful marine aquarium. It is the removal of unwanted substance primarily of ammonia from the water by bacteria. Ammonia comes from decaying organic matter like uneaten food and it is one of the primary excretory products of marine organisms. Biological filteration is solely the work of the bacteria attached to the surface of the gravel. The gravel and the subgravel filter together constitute the filter bed. Bacteria grows in these gravel and as the water ages their number increases until the gravel teems with them. Then only does your aquarium truly function well.

Setting up of a biological filter

A subgravel filter consists of a perforated plastic plate that covers the tank bottom from wall to wall with gravel spread over it to required height. There is a space between the filter and tank bottom. The water will pass through the sand and get collected at the space below the filter. The filtered water from the bottom of the filter is returned to the surface of the tank through air lifts built on to the bottom of the tank. Coral sand is usually used as the filter medium. Filter medium should be of a minimum 4 inch thickness. Three to four rows of interconnected perforated PVC pipes can also be used for the collection of filtered water instead of perforated plastic sheet. These pipes are kept at the bottom of the tank and coral sand is spread over it to a thickness of 4 ". Two pipes were connected vertically to these pipes inorder to bring the filtered water to the surface by air lifting.

Air lifting is done by placing an aeration stone connected to an air pump inside the vertical pipe. Stone should be placed at the bottom of the pipe otherwise air lifting may not be efficient. Air pump should have enough capacity to lift the water from the bottom of the tank.

Conditioning of filter bed

The first two weeks are critical for a new aquarium. During this time, the amount of ammonia is likely to rise because not enough nitrifying bacteria have established themselves in the gravel to convert it. Once the bacteria population has stablised with a steady point on food in the form of ammonia and organic matter, the aquarium is conditioned.

Since it takes 2 to 4 weeks to condition a new filter bed it is desirable to speed up the conditioning process. The best way is to take some gravel from an already conditioned filter and add it to a new filter. Bacteria in the conditioned filter will rapidly spread viable bacteria throughout the new filter bed. The conditioning process can be cut into half by using this method. There are other method which are not so fast as the previous one. Introduce hardy inexpensive fishes like tilapia or groupers into the tank. Rear them for atleast for two weeks, feeding them regularly the required food. After two weeks remove these animals and add a slightly small quantity of fishes you intend to keep. Another method is to add few animals at a time. In a small aquarium add one at a time, a week apart. This give the filter beds ample time to adjust to each new increase in ammonia. In general it is observed that when the total ammonia level fallen less than 0.1 ppm, a new aquarium can be considered as safe for animals.

Water quality parameters

Periodical checking of water quality is critical to a successful marine aquarium keeping.

Ammonia : Acceptable range is less than 0.01 ppm un ionised ammonia (NH_3). Both ionised and unionsied ammonia is present in the water, but the unionised form is lethal to the fishes. Percentage of unionised ammonia varies with temperature and pH of the water. If you are determining the total ammonia, the value should be converted to unionised ammonia. With same temperature, the percentage of unionised ammonia will be higher in high pH than in low pH.

Nitrite: Less than 0.1 ppm as nitrite ion is acceptable. Although nitrite ion is not so toxic to fishes its checking will help you to monitor the efficiency of the filter bed.

Nitrate: Less than 20 ppm as nitrate ion.

Dissolved oxygen: Not less than 1.0 ppm below saturation at any given temperature, with 5.0 ppm being the absolute lowest limit.

pH: The acceptable range is 7.5 to 8.3

Salinity: Salinity ranges between 28 to 32 ppm.

Maintenance

The loose brown dirt lying on the gravel, the detritus, although not harmful should be removed. The easiest way to remove it is to siphon it out during partial water exchange. Algae attached to the glass are not so harmful to the animals. In fact it serves as an excellent food for some of the invertebrates and fishes. Algae can be removed from the glass tanks with a sponge on a stick. Algae on the tank decorations and gravel should be left alone unless it becomes excessive, in which case take it out and scrub them with a stiff bristle brush and tap water. Then shake them dry and put them back. Gravel can be gently stirred to, loosen surface algae. The material can then be removed with a fine mesh net, siphon etc.

Water changes

About 10 % of the tank water should be changed every two weeks or a monthly exchange of 25 % is enough. The replacement water should be of same temperature and salinity of the tank water. Partial water exchange lowers the nitrate level, replenishes depleted trace metals and it is a convenient means of accumulated detritus and algae.

Selection of healthy animals

One secret to being a successful marine aquarist is picking healthy animals right from the start.

Colour : The colours of a healthy fish are bright and clear.

Skin condition: The skin should be clear. The skin should be free of any blemishes. There should be no discoloured or whitish patches over the body or the eyes.

Breathing and swimming: These should be normal. Any difference in breathing and swimming could be a sign of disease.

General behaviour: Fish should have normal patterns of feeding, resting and defending its territory. A fish showing signs of not being able to hold a territory is not a good fish.

Starvation: Starved fishes can easily be spotted by examining the area of the back just above the backbone. If the flesh is compressed, as if someone picked up the fish and pinched in between the fingers, then it is suffering from starvation. These fishes should be avoided.

Acclimation

Acclimation of the new animals to the new environment should be accomplished smoothly and with minimum stress. This could be done by keeping the bag with the fish in the tank for sufficient time to make the temperature same. Also an air stone can be placed inside the

bag inorder to keep the oxygen level. In every 15 min. add little of the tank water to the bag. This will gradually get the fish used to difference in chemical content.

Selection of fishes for aquarium

The coral reef fishes are the epitome of the aquarium keeping, but many fishes like the butterfly fishes and angel fishes are difficult to maintain. These fishes are suitable only to experienced aquarist. As a beginner your selection must be basically oriented towards the hardier species. For beginner's Pomacentrids damsel fishes, humbugs, clown fishes are more suitable. Some small groupers, which are quite hardy and colourful, are also recommended for beginners. Beginners might also choose from a variety of triggerfishes and filefishes,batfishes,lionfishes and gobies. When you get more experienced with the hardier fishes you might try some of the wrasses, tangs or even butterfly fishes.

While introducing fishes into tanks compatibility of fishes should be considered. A large carnivorous fish along with small fishes or fishes which fight with each other till death should be avoided.

Feeding

Although most fishes you might keep can adapt to some extent to diets different from those they were used to in their natural habitat, it is best to try and come as close as possible to their natural habitat. This keeps them healthier, more active , in better colour and growing normally. In the market a wide variety of aquarium feeds like frozen crustaceans (crab, shrimp,planktonic crustaceans) fishes squids are available. Another important feed is brine shrimp. It can be given in both live and frozen form. Many brands of flake foods of high nutritional value are available. Along with these foods live shrimps, crabs and other small crustaceans, clams can also be given to fishes.

Feed your fishes atleast twice a day. Feed small portions a little at a time and make sure that fishes are eating the feed. Also make sure that every fish gets its own share. Feed the fishes till it loses its interest in feeding. After feeding, remove all the uneaten food from the bottom of the tank. Food given to fishes should of the proper size. The size of the mouth is usually a good indicator of the size of food needed. Marine aquarium animals may be maintained in good condition for years on a combination of prepared food , raw seafood and adult brine shrimp. It is a best practice to offer a variety of feeds daily.

Diseases

Diseases caused by bacteria and protozoans are common in the marine aquaria. Loss of appetite, loss of coordination, hemorrhage of the skin weight loss, loss of tissues in the fin edges etc. are some of the signs of diseases.

Now a days many antibacterials and other chemicals are readily available in the market. If a parasite is observed in fish, a freshwater bath will be sufficient to remove it. If infection is too severe, a formalin bath will cure it. In case of a bacterial infection characterised by ragged fins and reddened areas at the base of the fins, clouded eyes etc., use of broad spectrum antibiotics like Chloromycin, Gentamycin are found effective. Fungal infections can be controlled by using formalin, hydrogen peroxide etc.

Most fish that are infected must be separated from the rest of the stock in treatment aquaria. Before treating an infected fish, read the instructions for using the medicine and give the correct recommended dose.

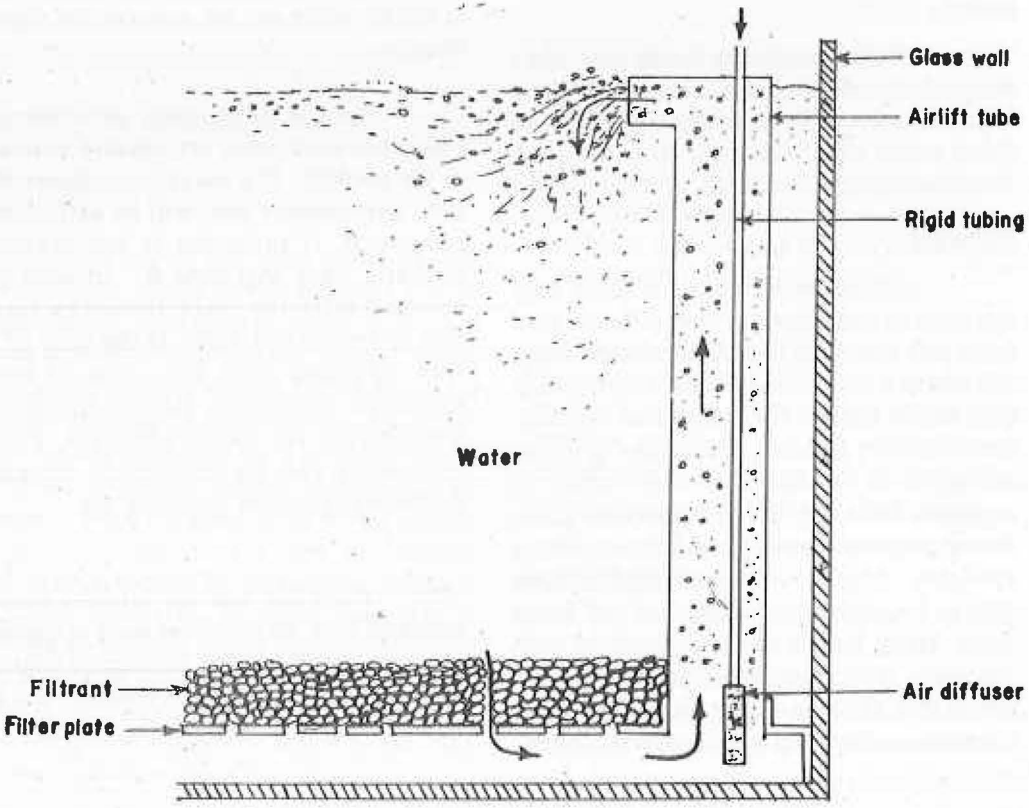
Decorations

Decorations are done to a marine aquarium not only to make the tank attractive, but also to make fishes feel at home. So it is important to make the tank as natural as possible. If you are keeping coral - reef fishes in the tank, every effort should be made to provide corals in the aquarium tanks. When the right combination of fishes and decorations is used the end result is a stunning rendition of nature. Dead corals, stones, drift wood and fibre glass decorations are the common things used in the marine aquarium for decorations. While adding these things to the tanks, it should be cleaned and washed thoroughly.

The objects you add to your aquarium should be pertinent to the theme of the exhibitand pleasing to look at, but they must also be chemically safe and attractive. When approached thoughtfully, decorating the aquarium can be a means of creative expression.

The success of keeping a marine aquarium is measu
time its inhabitants are kept alive, their health and sparkling clarity of water, but also by the number of breeding being reported. Breeding in your tank shows that you are providing the fishes a condition similar to its natural environment. In the institute's aquarium we were able to breed and produce juveniles of clown fishes, and sea horses. Also we were successful in making other fishes like *Abudefduf* spp. and other damsels mature in the aquaria tanks.

Diagram of Biological filter



Bio Active Compounds from Gulf of Mannar Resources

I. Rajendran
Regional Centre of Central Marine Fisheries Research Institute,
Marine Fisheries - 623 520, Ramanathapuram District, Tamil Nadu.

Introduction

Man has been venturing the oceans for his livelihood since ancient time. i.e. One century B.C. as recorded by Pliny the Elder. Of the wealth of oceans viz. fish, algae, mangroves, corals, minerals, natural gas and petroleum, fish by-catches, shells, etc., fishes substitute the major animal protein demand of the increasing world population. About 60% of the population of the developing countries derive 40% or more of their total animal protein from fishes. As the population is increasing alarmingly mainly in developing countries, controlled and sustainable sea resources exploitation are to be kept in mind. As the terrestrial exploitation to some extent has lead to non-sustainable state now, alarm has started from different parts of the world to control the global destabilization like green house effect, global warming, etc. To overcome these, oceans have been the point of attraction for sustenance and as a result oceans uncover many new things of nature hitherto unknown.

Noted among them are the potential value added products like drugs, toxins, pharmaceuticals and novel organic compounds. Reason on for this exploitation, it is needless to say, is the existence of folklore medical practices among aborigins and the modern human beings, dependant on marine resources. With the advent of modern chemical methods and sophisticated instruments, systematic exploration and investigation of marine sector for its resources have been triggered to unravel the hither to 'untapped marine products.

Seas of Mandapam

Gulf of Mannar and Palk Bay being the natural gift to the Indian coast have been in a strategic position to house myriads of oceanic resources. This is unique in marine resource diversity with 21 islands starting from Rameswaram to Tuticorin. Echinoderms, gorgonids, sponges, molluses, crustaceans and marine algae apart from fin fishes are extensively available in this region.

Sea horse

Some traditional medical practices with marine food are followed by the local people to cure some diseases. It is interesting to note that the dry power of sea horse is mixed with honey and consumed to cure asthma. Now sea horse is mainly exported to Singapore from the coastal town of Kilakkarai. Sea cow, ***Dugong dugon and sea turtles, Chelonia mydas, Lepidochelys olivacea*** are consumed to cure piles. Of course, sea cow is now an endangered one and banned from poaching.

Exploration of Marine Resources

Exploration of marine natural products started only 30 years back and it took new turn with the development of taxonomical work for species identification of marine flora and fauna. The emergence of new field of biotechnology paves the way for new techniques for isolation and purification methods of active components of the marine organisms. In this way nearly 7000 natural products have been isolated so far and their bioactivity studied. The chemical compounds include organic acids. carbohydrates, proteins, amino acids, steroides, lipids, enzymes, etc. The bioactivity studies include the properties of anibiotic, antitumor, anticoagulant, antiviral, antiulcer, haemolytic, analgesic, antilipemic cardioinhibitory, stimulating, depressants, fungicides, insecticides, pharmaceutical adjuvants, stabilizers, etc. The research on marine organisms for newer products is the timely one as the ocean appears to be a good alternative source of unique materials. The organisms found in the seas of Mandapam area are fascinating as the source of many bioactive compounds.

Invoking the general quality of sea foods, dietary fat of fish is a good source of essential fatty acids. Fish meat is rich in vitamin B complex. Fish liver oil is rich in vitamins A and D. Oysters are good source of iron and copper. Micronutrients like Ca, P, Na, Fe and easily accessible from sea foods. Sperm whale fat is the source of series of fatty acids. Perfumary compounds are synthesized from some of these constituent fatty acids.

As the accessibility of marine specimens is not readily possible unlike the one on land, this work limits to various skilled tactics like modern underwater exploration techniques with specialized vessels, SCUBA diving, skin diving and employing professional divers.

Echinoderms

Gulf of Mannar and Palk Bay are rich in echinoderms like sea cucumber, star fishes and sea urchins. Sea cucumbers, ***Holothuria atra, H. scabra*** and ***H. spinifera*** have overseas market for delicious dishes prepared from their deviscerated and cured products. Their body wall contains saponins (glycosidic steroids) and holothurin compounds which are ichthyotoxic in nature. This property was studied on fish fingerlings, mice and erythrocytes (haemolytic activity).

Bech-de-mer, a processed form of sea cucumber has the curative power for ailments like high blood pressure and muscular disorders. In the Philippines, the cuverian tubules are used as a crude plaster for minor wounds. Star fishes also contain saponins called asterosaponins. Toxins of echinoderms are soluble in water and alcohol. They possess antifungal, antiviral properties as revealed from the test on influenza virus B in the chicken embryo. The saponins of star fishes ***Asterias forbesi, Acanthaster Planci*** and ***Asterina Pectinifera*** structurally contain cholestane type aglycone, sulphate group and sugar moieties.

Sea hares, ***Aplysia*** spp. excreat irritating substances which have toxic neuromuscular effects when tested on mice resulting in paralysis. Cray fish, ***Jasus islandi*** contains oxygenated cholestanes like crustecdysone which plays an important role in insect metamorphosis including moulting in crustaceans.

Gorgonids

They are corals of the order ***Gorgonacea*** having flexible branched skeleton of horny material. These plant like organisms are extensively seen in the seas of Mandapam. They contain compounds having significant bioactivity. Gorgonian, ***Juncella juncea*** on methylene chloride extraction yields a compound which has been found to inhibit the settlement of barnacle of ***Balanus amphitrite.*** It was identified as disterpenoid compound and thus have an immense value as an antifouling agent. Another gorgonian coral, ***Plexaura homomalla*** contains significant quantity of prostaglandins (PGs). These compounds are medicinally important used for cellular level biochemical actions, in birth control measures, in renal pathology and in the treatment of intestinal ulcers. Di-and sesquiterpenes are obtained from ***Eunicea mammosa*** and they inhibit the growth of ***S. aureus*** and ***Clostridium*** spp.

Sponges

They are calcareous or siliceous spicules having porous skeleton. A toxic sponge, ***Sigmadocia fibulata*** contains antiviral compound. It is found in Hare Island of Gulf of Mannar. The extract of another sponge ***Placospongia carinata*** exhibits antimicrobial activity against ***Bacillus*** and ***Pseudomonas*** spp. Sponge like ***Spongia officinalis*** contains bioactive peptides (adrenergic) and furanoterpenes like furospongin and isofurospongin. They inhibit the growth of ***S. aureus*** and ***B. subtilis.*** Unusual nucleosides like spongouridine and spongothymidine are obtained from sponges like ***Crytotethya crypta.*** They provide models for antitumor nucleic acid antagonists. The resistance of sponges to bacterial decomposition has obviously attracted investigators for any causative agents to be present. On investigation it was found out that they contained antibiotic compounds which protect them from harmful microbes.These organisms have an efficient canal system by which they extract chemical substances from the seawater. A few hundred sponge species have been studied and many extracts have showed wide spectrum of antibiotic activity against gram+ve and gram -ve organisms. Sponges, ***Verongia acrophoba*** yielded aeroplysinin-I and it showed resistance to ***S. alba, B. cercus*** and ***B. subtilis***. Broma phenol and brominated pyrrole compounds having antibiotic activity were isolated from sponges, ***Dysidea herbacea*** and ***Phakellia flabellata.***

Gastropods

Opisthobraches and other gastropods are the source of variety of bioactive compounds. A pulmonate gastropod (shell is absent), ***Onchidium verruculatum*** available near Tuticorin, has toxic compounds. The MeOH-CH_2 Cl_2 extract of this animal is toxic to ***Artemia salina*** and inhibited the growth of ***Isochrysis galbana.*** It also repels fishes and crabs.

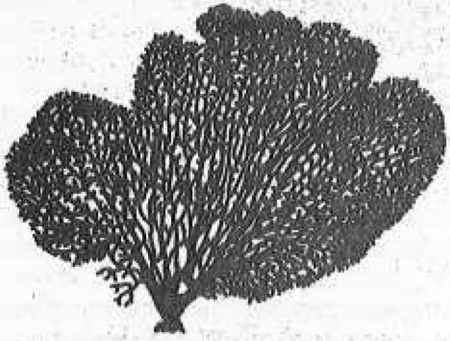
Other organism

Colonial zoanthid of the genus ***Zoanthus*** contains novel alkaloids that possess anti - inflammatory and analgesic properties. Sea anemone, ***Actinia equina*** contains a quaternary ammonium compounds (QAC), tetramethyl ammonium hydroxide which has paralytic activity. Another QAC, hormarine isolated from sea anemone has the effect of decreasing heart beat and cause cardiac arrest at high concentrations. Bioactive peptides are isolated from these animals and they are cardiotonic.

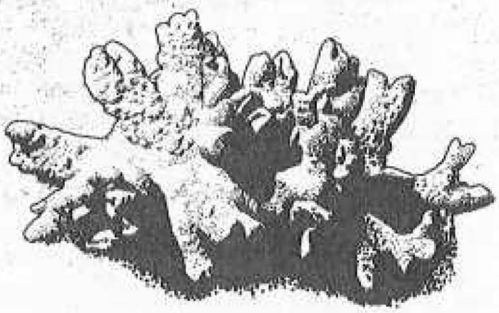
Microbial flora, ***Cephalosporium acremonium*** (a sea water fungi) contains cephlosporin C which has broad spectrum activity against gram +ve and gram - ve bacteria. They arrest the proliferation of infectious microbes of sea water to provide hygienic environment.

Marine alga (Sea weeds) and Mangrove

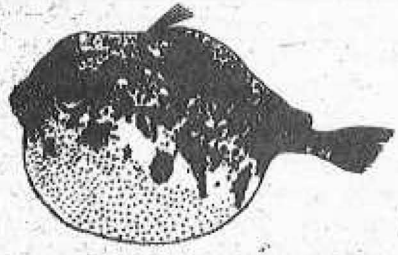
Marine algae contribute the major source of variety of bioactive compounds. Gulf of Mannar and Palk Bay coasts are abundant with many varieties of seaweeds. Agar is a valuable



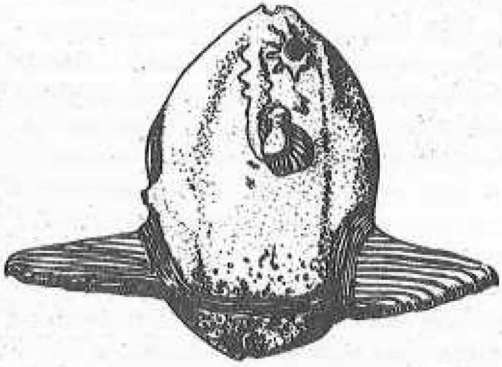
Sea fan



Sponge



Puffer Fish



Sun Fish

product of red seaweeds, ***Gelidium*** and ***Gracilaria*** spp. Agar contains agarose (neutral polysaccharide) and agaropection (acidic poysaccharide). It is widely used as emulsifying agent in pharmaceutical formulations. Various grades of agar are prepared by chemical treatments. The refined form is used in microbiological work as bacterial culture media. Carrageenan, another important product of red algae ***Gigartina*** spp. is used as antiviral compound for certain influenza viruses and also as antiucler agent. Alginic acid and alginates are extracted from brown algae, eg. ***Laminaria*** spp. It is anticoagulant in absorbable haemostatic materials for the control of surface bleeding. Lipids of ***Hypnea muciformis*** shows inhibition against ***Sarcina lutea*** and ***E.coli.;*** of ***Enteromorpha*** spp. ***(intestinalis)*** against ***S. lutea, B. subtilis, E.coli,*** and ***C.albicans.***

Extracts of ***Padina teterastromatica, Gelidiella acerosa*** and ***Acanthophora spicifera*** show antifertility activity thus having promise in birth control measures. These extracts contain fatty acids, novel steroids and dipeptides. A deterpene isolated from ***Dyctyota*** spp. ***(dichotoma)*** has anti bacterial, antiviral and ichthyotoxic properties. A sphingosine derivative of palmitic acid isolated from green algae ***Ulva faciata*** is a potential antiviral compound.

Mangroves like ***Acanthus ilicifolius, Avicennia marina*** and ***Excoecaria agallocha*** contain active compounds in their root, leaf and flower and they have analgesic activity.

Marine Toxins

Though the delicious marine food animals are enjoyed during consumption sometimes they turnout to be dangerous due to toxins accumulated in them resulting in sea food poisoning. Of the total estimated 2500 specious of fishes, 700 are designated as poisonous. Marine toxins form an important part among the marine natural products as it poses an environmental problem on its incidence and draw immediate attention to cure the affected persons. They are of extensive pharmacological interest, as they are used in treating many dreadful diseases at controlled doses. Characterization, of these toxins leads to the discovery of their antidotes. They form an important models in developing new drugs as neuromuscular relaxant, local anaesthetics, etc.

Tetrodotoxin, present in puffer fish ***(Tetrodon*** spp***)*** is chemically a polyhydroxylated perhydromethyl quinazoline compound. At lower dose, it is useful as muscle relaxant and pain killer in neurogenic leprosy and terminal cancer. Toxins of porcupine fish, ***Diodontidae*** and sunfish, ***Molidae*** also come in this group. Ciguatoxin is primarily derived from dinoflagellate, ***Gambierdiscus toxicus*** and percolates to fishs through food, chain. About 400 specious of marine fishes have been implicated with ciguatoxicity. It was first reported on injestion of marine snails of Carribean areas. Saxitoxin and gonyaulax toxins are derived from dinoflagellate, ***Gonyaulax catenella*** and reaches clams and crabs by the food cycle.

Pahutoxin is excreated by box fish, ***Ostracion lentiginosus,*** as a defensive substance to upset other fishes It is 3-ace toxyhexadecanoyl choline. It has surfactant and haemolytic properties. A peptide toxin is secreated by mucus producing glands of soap fish, ***Rypticus Saponaccus.*** They produce haemolytic effect and disturbance on predators.

Conclusion

The potential use of many of these marine bioactive compounds thus depends onproper isolation and characterisation.

Oceans are provided with immense treasure, thus throwing open many areas of multidisciplinary work. The novelty of many marine derived compounds and their wide spectrum of applications may find way in getting solution to many dreadful diseases like AIDS, Cancer, Alzheimer's disease and arthritis which are difficult to be cured even today.

Crabs and Crab Fishery of the Mandapam Area

Josileen Jose
Regional Centre of Marine Fisheries Research Institute
Marine Fisheries -623 520, Ramanathapuram District, Tamilnadu.

In our country, crab fishery is mainly contributed by portunid crabs those which belong to three generae ie., **Scylla, Portunus and Charybdis.** They have the typical portunid shape with carapace having 4-9 anterolateral teeth. Chelepeds are longer than all legs and last pair typically paddle shaped. Their systematic position is as follows:

Phylum	:	Arthropoda
Class	:	Crustacea
Sub-Class	:	Malacostraca
Order	:	Decapoda
Suborder	:	Brachyura
Family	:	Portunidae
Subfamily	:	Portuninae

These are commonly referred to as edible crabs, inhabiting the coastal waters and adjoining brackish water environments support localised sustenance fishery of some importance. The commercially important crabs which are available in the seas around the Mandapam region are as follows:

Scientific Name		Vernacular Name
Scylla serrate	:	Chambanandu
Scylla tranquebarica	:	Kazhinandu
Portunus pelagicus	:	Olakkalnandu or Kadal nandu
Portunus sanquinolentus	:	Mookkannu Nandu
Charybdis feriatus	:	Siluvai nandu
Charybdis annulata		
Charybdis natator		

Among these crabs, at Mandapam region a major fishery is existing for ***Portunus pelagicus*** only and for scylla spp. to a little extent.

Portunus pelagicus commonly known as blue swimmer crab, its distribution ranges from Red Sea, Mediterranean, east coast of Africa, Persian Gulf, Pakistan, India, Sri Lanka, Mergui Archipelago, Singapore and Philippines to Australia, New Zealand, Tahiti, China sea and Japan.

In India it is well distributed along the east and west coasts and fished from all the maritime states, some of the estuaries and brackish water areas. The major share comes from the Tamil Nadu that too from a small area along the Palk Bay and Gulf of Mannar.

Male crabs are characterised by the inverted 'T' shaped abdomen and female crabs with semicircular abdomen. In ***P. pelagicus*** one can easily distinguish the sex from its colour pattern. Males are more attractive, the carapace is light brown coloured with typical 'mosaic' markings and tips of legs are with bright blue colour, hence the name 'blue swimmer crabs'. The carapace of the female crab is dark brown, with comparatively smaller markings than the male crab and tips of the legs end in rust/brown colour.

A regular fishery of ***Portunus pelagicus*** exists in this region, though it is not at all commercially developed as in other countries. At Palk Bay side of Mandapam, fishing is a year round process and crab are landed as a bycatch in trawl nets. In the Gulf of Mannar, fishing is seasonal, for a period of six months, from

October to March. Majority of the trawlers go for night fishing and rest for day-night fishing. Trawlers operate upto a depth of 50m, generally operates below 25m of depth. Average annual crab landings from Palk Bay is about 178 t and catch per boat is 4.3 kg. In the overall catch ***P. pelagicus*** forms about 3.7%. At Gulf of Mannar average catch comes around 10 t/year, catch per boat is 1.2 kg and crab forms 4.5% of the overall catch. The maximum crab landings is recorded in the months of June and December at Palk Bay and Gulf of Mannar respectively.

In trawl catches females are dominating in most of the months. Major portion of the fishery is contributed by 100-160 mm (carapace width) size groups. ***Portunus pelagicus*** is a continous breeder and berried crabs (crabs with eggs) are included in the catch throughout the year. A small percentage of parasite infected crabs also observed in the landings in most of the months.

The traditional gill net, locally known as "nanduvalai" is widely used for crab fishing in this region. Devipattinam (Palk Bay) and Thoppukkadu (Gulf of Mannar) are the two centres where 'nanduvalai' fishing is prevalent throughout the year. A group of 3-5 fishermen go for fishing in a vallam, locally known as "Vathai". Overall length of the craft is 7-8 m and a single craft carries 15-25 nets depending on the number of the crew. A single fisherman can carry five "nanduvalai" and hence the total number of nets depend on the crew. Each "nanduvalai" is about 200m in length and one metre in width or height. The body of the net is made of high density nylon monofilament rope with a square mesh of 80mm. The head rope is of thick nylon and small rubber pieces are tied to it as floats at regular intervals of one and half feet. The foot rope is made of cotton, which absorbs water and therefore no sinkers are necessary. This is the type of crabnet used at Devipattinam, however variationus have been noticed in size and other aspects of crab nets used in different localities.

"Nanduvalai" are used in fleets, several of them are tied end to end forming a long chain so that they cover a considerable area in the sea. The fishing grounds are restricted to shallow water regions of the coast at depths upto 15 metres, generally in the 4-5 m area. Fishermen go for fishing during evening hours, carrying the fleet of these nets. One person handles the "Vallam", while others lay the net which is always parellel to the coastal line. The crabs which cross the long chain of net get themselves entangled in the meshes and cling to the nets. The fishermen carefully remove the entangled crabs with much care without breaking its appendages.

At Devipattinam average crab catch is 36 t/year with an average boat catch of 16 kg and at Thoppukkadu total catch is 6t/year and boat catch is 2 kg. Males dominated the 'nanduvalai' catches and occurrence of berried crabs are less compared to the trawler catches. Crab catches are mainly composed of sizes ranging between 80 - 150 mm in carapace width. Parasite infected crabs are also caught in nanduvalai during certain months. At Thoppukkadu, apart form ***P. pelagicus, Scylla tranquebarica*** is also caught in 'nanduvalai' and average production is 2.6 t/year.

The catches are either sold in the markets or to the wholesale crab merchants, from there to processing units. There is a good demand for ***P. pelagicus*** and it fetches an average price Rs.35-45/Kg. and during certain season it has even gone upto Rs.75/Kg. The meat is very tasty, contains 16-20% protein and some believe that meat is good for curing asthmatic problems.

At present there is no fishing regulations for the crab fishery. If we observe the past few years data it is clear that catches are fluctuating and eventhough fishing effort has increased than the previous decades, total

landings has not increased in accord. It is high time to put some specific management regulations for minimum size at capture and protection for females bearing eggs. Moreover, awareness must be given to the fishermen to release back the berried females to the sea and there by ensure that females are not sold with their berries.

Seed production of ***Portunus pelagicus*** has been standardised by CMFRI recently. Some of the Government as well as public organisations must takeup sea ranching programme to ensure the sustainability of the stock and also to augment the wild production.

Seaweed exploitation and Industry in India

S.Kalimuthu
Regional Centre of Marine Fisheries Research Institute
Marine Fisheries -623 520, Ramanathapuram District, Tamilnadu.

Since the inception of Central Marine Fisheries Research Institute at Mandapam in 1947, research on seaweeds and their utilisation is being carried out. Later on research on Indian seaweeds was started by Central Salt & Marine Chemicals Research Institute, Bhavnagar, National Institute of Oceanography, Goa and some State Government Fisheries Departments. In addition Universities of Madras, Annamalai, Andhra and Kerala have also started investigations on various aspects of seaweeds and seagrasses. These studies made by various organisations have contributed to the development of agar and algin industries in India.

Seaweeds are the only source for the production of phytochemicals such as agar, carrageenan and algin which are widely used as human food, animal feed and manure. Seaweeds grow submerged in intertidal, shallow and deepwaters upto 180 m depth in the sea and also in estuaries and backwaters. Seaweeds grow abundantly along Tamil Nadu and Gujarat coast and in Lakshadweep and Andaman-Nicobar archipelagos. There are also rich seaweed beds around Mumbai, Ratnagiri, Goa, Karwar, Varkala, Vizhinjam and Visakhapatnam coast and in the Ashtamudi, Pulicat and Chilka Lakes.

In India seaweeds are exploited commercially from Tamilnadu coast since 1966 and they were exported to foreign countries till 1970. After agar and algin industries were started in the country in 1970, the export of seaweeds was banned. During the last five years some quantity of ***Gracilaria verrucosa*** collected from Chilka lake was exported to Japan. At present the seaweeds harvested from the natural seaweed beds of Tamil Nadu coast are used only for the manufacture of agar, alginates and liquid seaweed fertilizer. The red algae ***Geldiella acerosa, Gracilaria edulis, G.crassa*** and ***G.foliifera*** are used for extracting agar and ***Sargassum*** spp ***Turbinaria*** spp and ***Cystoseira trinodis*** are used for alginates. There are 22 units producing agar and 18 units producing alginates. Most of them are small scale industries without much sophisticated machineries.

The commercial exploitation of seaweeds is concentrated for several years only along south Tamilnadu coast from Rameswaram to Kanyakumari. The natural resources of algin yielding seaweeds ***Sargassum*** and ***Turbinaria*** in Tamilnadu coast are adequate. At present only about 50% of these plants is harvested. The agarophytes ***Gelidiella acerosa*** and ***Gracilaria edulis*** are not available in sufficient quantities to meet the raw material requirement of the agar industries. Hence other species of ***Gracilaria*** such as ***G.foliifera*** and ***G.crassa*** are harvested for agar production whenever there is scarcity for ***G.edulis.*** This paucity of ***G.edulis*** came to an end after the collection of free floating ***G.edulis*** from Kottaipattanam - Chinnamanai area in the Palk Bay side since 1990.

Data collected by the Central Marine Fisheries Research Institute during the last 22 years from 1978 to 1999 show that the quantity of agarophytes harvested ranged from 248 to 1296 tonnes (dry wt) and alginophytes from 651 to 5537 tonnes (dry wt) in a year. An average of 50 tons of agar and 500 tons of alginates are produced annually in India and some quantity of agar and alginates is exported to foreign countries such as Malaysia, Singa-

pore, U.A.E. and Saudi Arabia. The present marketing rate for food grade agar is Rs.200 to 250/- and for B.G. grade agar is Rs.500 to 600/kg. The cost of Sodium alginate is Rs.100 to 150 per kg. The rate for the raw material of ***Geldiella acerosa*** is Rs.12,000, ***Gracilaria*** spp Rs.4000 and for ***Sargassum*** spp. ***Turbinaria*** spp and ***Cystoseira trinodis*** is 2500 per tonne (dry wt)

As the demand for agar is increasing and new units are being set up, exploitation of agarophytes will increase. The existing agar manufacturers can take up carrageenan production also using ***Hypnea*** spp as raw material or by using imported ***Eucheuma*** and ***Kappaphycus.*** The agar, algin and carrageenan yielding seaweeds growing in harvestable quantities in other parts of Indian coast, Lakshadweep and Andaman-Nicobar islands (Table 1) may be exploited during their maximum growth periods.

Based on the studies made by the Central Marine Fisheries Research Institute on the growth, fruiting behaviour, effect of repeated harvesting on the growth and phycocolloid contents of agar, algin and carrageenan yielding seaweeds of Tamil Nadu, a time-table for commercial harvest of these seaweeds is given in Table 2. In order to. conserve the natural stock of economically important seaweeds of Tamilnadu coast and also to get consistant crop every year, the seaweed harvestors should follow this time-table. This will ensure regeneration and regrowth of seaweeds by vegetative and reproductive growth to harvestable size plants in the next harvesting season by means of giving sufficient interval between one harvest and the other. A single harvest in a year is recommended for all species. However the harvest may be done twice in a year during the periods indicated in Table 2 for ***Gelidiella acerosa*** and ***Gracilaria*** spp in areas with rich growth of these algae.

Cultivation of agar yielding seaweeds could form additional source for supply of raw materials to Indian agar industries. The CMFRI has developed viable technology for the commercial scale cultivation of agar yielding seaweed ***Gracilaria edulis*** using coir rope net method and Central Salt & Marine Chemicals Research Institute for ***Gelidiella acerosa*** using coral stone method. The bays and creeks present in the open shore along the east and west coast, lagoons of coral reefs in the southeast coast of Tamilnadu, Andaman-Nicobar islands and atolls of Lakshadweep have immense potential for cultivation of seaweeds. The commercial scale cultivation of seaweeds may be undertaken in these areas by the seaweed utilisers and private entrepreneurs by availing the financial assistance from banks and other funding agencies connected with rural development programmes. Seaweed cultivation on large scale could not only augment supply of raw material to the seaweed industries, but it would also provide employment to the people living in the coastal areas of mainland, Lakshadweep and Andaman-Nicobar Islands. This would help in improving their economic status and thus help in rural upliftment.

Table 1. Occurrence of agar, carrageenan and algin yielding seaweeds in other parts of Indian Coast

Name of the seaweed	Place of occurrence
Agarophytes	
Gelidiella acerosa	Okha, Dwarka, Porbandar, Diu, Veraval, Lakshadweep and Andaman-Nicobar
Gracilaria edulis	Lakshadweep and Andaman-Nicobar
G.crassa	Andaman-Nicobar

G.corticata var corticata	Dwaraka. Bombay Karwar, Goa, Tikkoti Quilon, Varkala, Vizhinjam. Visakhapatnam and Andaman - Nicobar.
G.foliifera	Gopnath, Okha, Bombay, Tikkoti and Andaman-Nicobar
G.verrucosa	Okha, Bombay, Goa, Chilka and Andaman-Nicobar
Alginophytes	
Sargassum wightii	Bombay, Goa, Alleppey, Vizhinjam and Andaman-Nicobar
S.tenerrimum	Gulf of Kutch, Okha, Dwaraka, Bombay, Goa, Karwar, Visakhapatnam and Andaman-Nicobar
S.myriocystum	Andaman-Nicobar
S.ilicifolium	Bombay, Goa, Karwar, Visakhapatnam and Andaman-Nicobar
S.cinereum var berberifolia	Gulf of Kutch, Bombay, Goa, Karwar and Vishinjam.
S.johnstonii	Okha
S.vulgare	Dwaraka, Okha and Visakhapatnam
S.duplicatum	Lakshadweep and Andaman-Nicobar
T.ornata	Dwarka, Lakshadweep and Andaman-Nicobar
T.decurrens	Andaman-Nicobar
Cystoseira trinodis	Okha and Andaman-Nicobar
Hormophysa triquetra	Okha and Andaman-Nicobar
Carrageenophytes	
Hypnea musciformis	Gopnath, Okha, Dwarka, Bombay, Goa, Karwar, Visakhapatnam, Lakshadweep and Andaman-Nicobar
H.valentiae	Bombay, Tikkoti, Vizhinjam and Lakshadweep

Table 2. Time-Table for commercial harvest of economically important seaweeds from Tamil Nadu Coast

Name of the seaweed	Period of Occurrence	Suitable period for harvest
Agarophytes		
Gelidiella acerosa	Throughout the year	January to Mary July to September
Gracilaria edulis	-do-	January to March & August to September
G.crassa	-do-	-do-
G.foliifera	-do-	-do-
G.corticata var. corticata	-do-	June to August November to December

G.verrucosa	March to November	May to August
Alginophytes		
Sargassum wightii	Through out the year	October to December
S.myriocystum	-do-	May to August
S.ilicifolium	-do-	July to September
Turbinaria conoides	-do-	October to December
T.ornata	-do-	-do-
T.decurrens	-do-	December - January
Carrageenophytes		
Hypnea musciformis	-do-	December to March
H.valentiae	-do-	January to March

SCIENTIFIC, COMMON AND TAMIL NAMES OF COMMERCIALLY IMPORTANT MARINE ORGANISMS OF GULF OF MANNAR.

A. Palanichamy,
Regional Centre of Central Marine Fisheries Research Institute,
Marine Fisheries - 623 520. Ramnad District, Tamil Nadu.

INTRODUCTION

The Gulf of Mannar coastal region contributes rich fauna and flora of sharks, rays, skates, fishes ornamental fishes, crabs, lobsters, prawns, gastropods, bivalves, sea cucumbers, marine mammals, gorgonids, sea turtles and seaweeds. All the marine organisms are useful in one way or other. In this paper the scientific, popular and local names of different marine organisms have been given in a serial manner. The fishermen of local area during the northeast monsoon period (October - February) exploit the fishes and other organisms with the help of different gears and crafts. The 14 islands around Mandapam are located as part of the discontinuous barrier reef, the Mannar barrier reef, with a variety of flora and fauna. This area attracts a lot of tourists and also the biologists.

Scientific Name	Common Name	Tamil Name
Sharks, Rays and skates -		சுறா, திருக்கை மற்றும் உளுவை
Manta birostris	Giant Devil ray	கொம்புத்திருக்கை
Dasyatis sephen	Cowtail ray	ஆடாதிருக்கை
D. bleekeri	White tail sting ray	மணத்திருக்கை
D. uarnak	Banded white tail sting ray	புளியன்திருக்கை
D. imbricata	Scaly sting ray	செந்திருக்கை
Aetobatus narinari	Spotted eagle ray	குருவித்திருக்கை
A. flagellum		சங்குவாயன்
Narcine spp	Electric ray	திமிலித்திருக்கை
Rhinoptera javanica	Javanese cow ray	வழுவாடித்திருக்கை
Gymnura micrura	Short tailed Butterfly ray	அட்டுவாணித்திருக்கை
Carcharhinus spp	Shark	சுறா

Scoliodon laticaudus	Yellow dog shark	பால் சுறா
Chiloscyllium indicum	Ridge-back cat shark	தாளன் சுறா (அ) குரங்கன் சுறா
Stegostoma fasciatum	Zebra shart	கோம்பறையன் சுறா
Sphyrna spp	Hammer head shark	கொம்பன் சுறா
Rhyncho batus djiddensis	White spotted shovel nose ray	பால் உளுவை
Rhinobatus granulatus	Granulated shovel nose ray	கல் உளுவை
Fishes		உணவு மீன்கள்
Leiognathus spp	Silver belly	காரல்மீன்
Caranx spp	Trevally	பாறைமீன்
Chorinemus spp	Leather skin	கட்டா மீன்
Gerres spp	Silvar biddy	ஊடகம் மீன்
Sardinella spp	Sardine	சூடைமீன்
Lethrinus spp	Pig face bream	விளமீன்
Stolephorous spp	Anchovy	நெத்திலிமீன்
Hemirhamphus spp	Half beak	முரல் மீன்
Siganus spp	Spine foot	ஓராமீன்
Sciaena spp	Jew fish	கத்தாளை மீன்
Mugil spp	Mullet	மணலைமீன்
Upeneus spp	Goat fish	நகரை மீன்
Sphyraena spp	Seapike	ஊழி (அ) ஊலா மீன்
Sillago spp	Whiting	கிழக்கன்மீன்
Saurida spp	Lizard fish	தண்ணி பண்ணா மீன்
Cybium spp	Seer fish	சீலா மீன்
Chirocentrus spp	Wolf herring	முள்ளுவாளை மீன்
Trichiurus spp	Ribbon fish	சாவாலை மீன்
Otolithus spp	Jew fish	பண்ணா மீன்
Epinephelus spp	Rock cod	கலவா மீன்

Stromateus spp	Pomfret	வாவல் மீன்
Dussumieria spp	Rainbow sardine	தொண்டன் மீன்
Polynemus spp	Tassel fish	கட்டித்காளை மீன்
Platycephalus spp	Flat head	கல்வெட்டி மீன்
Arius spp	Cat fish	கெழுத்தி மீன்
Chanos chanos	Milk fish	பாலை மீன்
Holocentrus spp	Red squirrel fish	செப்பிலி மீன்
Lates calcarifer	Gaint perch	கொடுவா மீன்
Rastrelliger kanagurta	Indian mackerel	கும்ளா மீன்
Lactarius lactarius	White fish	குதிப்பு மீன்
Sardinella longiceps	Oil Sardine	பேச்சாலை மீன்
Thunnus spp	Tuna	சூறை மீன்
Nemipterus spp	Threadfin breams	செந்நகரை மீன்
Cyanoglossus spp	Tongue sole	நாக்கு மீன் (அ) அடல் மீன்
Tylosurus spp	Fork tail alligator gar	வாளை முரல் மீன்
Ornamental fishes		வண்ண மீன்கள்
Chaetodon collaris	White collared coral fish	
Pterois volitans	Lion fish or scorpion fish	சாமி மீன்
Siganus canaliculatus	Rabbit fish	புள்ளி ஓரா மீன்
Siganus javus	-do -	வரி ஓரா மீன்
Callyodon ghobban	Parrot fish	கிளி மீன்
Amphiprion sebae	Yellow - tailed anemone fish	தாமரைக்காத்தான் மீன்
Gymnothorax spp	Moray eel	அஞ்சாலை மீன்
Cheilinus chlorurus	Wrasses	--
Acanthurus gaham	Surgeon fish	ஓரண்ட ஓரா மீன்
Abudefduf septemfasciatus	Demoiselles	செத்தை மீன்
Lactoria cornuta	Box fish	குட்டுளு மீன்

Hippo campus spp	Sea horse	கடல்குதிரை
Diodon hystrix	Porcupine fish	முள்ளுபேத்தை மீன்
Lutianus kasmira	Snappers	பருத்தி விலை மீன்
L. aretimaculatus	Mangroove red snapper	பருத்தி விலை மீன்
Holocentrus rubum	Red squirrel fish	செப்பிலி மீன்
Heniochus acuminatus	Pennant coral fish	--
Echeneis naucrates	Sucker fish	உருளை மீன் (அ) சப்பாத்தி மீன்
Monodactylus argenteus	Silver bat fish	செங்கனி பாறை மீன்
Platax teira	Long finned spade fish	கெள்ளல் மீன்
Apogon thermalis	Cardinal fish	சிலிந்தி மீன்
Tetrodon hispidus	Puffer fish	பேத்தை மீன்
Ostracion tuberculata	Ocellated Box fish	குட்ளு மீன்
Canthigaster margaritatus	Ocellated Toby	--
Crabs, Libster and Prawns		நண்டு, சிங்கி இரால் மற்றும் இரால்
Portunus sanguinolentus	Three spotted crab	முக்கன் நண்டு
Portunus pelagicus	Blue swimming crab	புள்ளி நண்டு
Scylla serrata	Green mud crab	சம்பா நண்டு (அ) களிநண்டு
Panulirus spp	Spiny lobster	சிங்கி இரால்
Thenus orientalis	Mud lobster	மட்டசிங்கி இரால்
Penaeus monodon	Giant Tiger Prawn	கருவண்டு இரால்
Penaeus semisulcatus	Green Tiger Prawn	வரி இரால்
Penaeus indicus	Indian white prawn	வெள்ளை இரால்
Molluses		சங்கு, சிப்பி மற்றும் கணவாய்
Xancus pyrum	Sacred chank	வெண்சங்கு
Pinctada fucata	Pearl oyster	முத்துச்சிப்பி
Sepia spp	Cuttle fish	ஒட்டுக்கனவா
Loligo spp	Squid	ஊசிகனவா
Octopus spp	octopus	கூந்தல் கனவா

Sea cucumber		கடல் அட்டை
Holothuria scabra	Sand fish	வெள்ளை அட்டை
Holothuria atra	Lolly fish	கருப்பு அட்டை
Holothuria spinifera	--	சீன அட்டை (அ) ராஜஅட்டை
Actinopyga echinites	Deepwater red fish	பார்அட்டை
mammals		கடல் பாலூட்டிகள்
Delphinus spp	Common Dolphin	ஓங்கி
Balenoptera spp	Baleen Whale	திமிங்கிலம்
Dugong dugon	Sea cow	ஆவுளியா (அ) கடல்பசு
Physeter macrocephalus	Great sperm Whale	திமிங்கிலம்
Gorgonoids		கடல் விசிறி
Echinomuricas	Red Type sea fan	கடல் விசிறி
Turtles		ஆமைகள்
Chelonia mydas	Green Turtle	பேராமை
Lepidochelys olivacea	Olive ridley turtle	பங்குனி ஆமை (அ)சித்தாமை
Dermochelys coriacea	Leatherback turtle	ஏழுவரி ஆமை (அ) தோணி ஆமை
Eretmochelys imbricata	Hawksbill turtle	அழுங்காமை
Caretta caretta	Logger head turtle	பெருந்தலை ஆமை
Seaweeds		கடல் பாசிகள்
Ulva lactuca	Sea lettuce	பட்டுப்பாசி
Caulerpa racemosa	--	மூக்குத்திப்பாசி
Caulerpa sertularioides	--	இறகுப்பாசி
Sargassum spp	--	கட்டக்கோரை பாசி
Turbinaria spp	--	பக்கோடாப் பாசி
Padina boergesenii	--	எலிக்காது பாசி
Cystoseira trinodis	--	மல்லிப்பாசி

Hydroclathrus clathratus	--	இடியாப்ப பாசி
Gelidiella acerosa	--	மரிக்கொழுந்து பாசி
Gracilaria edulis	--	கஞ்சிப்பாசி
Gracilaria crassa	--	வேர்ப்பாசி
Gracilaria verrucosa	--	கூந்தல்பாசி (அ) தாடிப்பாசி
Gracilaria foliifera	--	சிகரெட் பாசி
Hypnea valentiae	--	செம்பாசி
Acanthophora spicifera	--	முருக்குப்பாசி
Sarconema furcellatum	--	சக்களத்தி பாசி

Production of export quality agar

J.R.Ramalingam
Regional Centre of Marine Fisheries Research Institute
Marine Fisheries -623 520, Ramanathapuram District, Tamilnadu.

The seaweeds are the renewable and economically valuable wealth of the sea. The phytochemicals agar and algin are produced from the seaweeds. The red algae ***Gelidiella acerosa*** and ***Gracilaria edulis*** are the source of raw materials for agar industries and ***Sargassum*** and ***Turbinaria*** for algin industries. Annually 50 tons of agar and 500 tons of alginates are manufactured in India.

Two grades of agar are produced in India namely food grade and IP Grade. (Bacteriological grade). Gel strength is the main criteria for differentiating these two types of agar. ***Gracilaria edulis*** is used for food grade agar and ***Gelidiella acerosa*** for IP grade agar. The specifications for the food grade and IP grade agars are given below.

1. Food Grade Agar (Indian Bureau of Standards IS : 5707 - 1970)

Characteristics	Requirements
1. Water absorption	to pass the test
2. Moisture, % by weight on drying at 105° C for 5h, max.	20.0
3. Total ash, % by weight, max.	6.5
4. Acid insoluble ash, % by weight max.	1.0
5. Gelatin	to pass the test
6. Insoluable matter, % by weight max.	1.0
7. Starch and dextrin	to pass the test
8. Arsenic (as As), mg/kg max.	3.0
9. Lead (as Pb), mg/kg, max.	10.0

2. Bacteriological Grade Agar (Indian Bureau of Standards IS : 6850 - 1973)

Characteristics	Requirements
1. Moisture, % by mass on drying at 105°C for 5h, max.	to pass the test
2. Total ash, % by mass, max.	20.0
3. Acid insoluble ash, % by mass max.	1.0
4. Gelatin	to pass the test
5. Insoluble matter, % by mass, max.	1.0
6. Arsenic (as As) mg/kg	3.0
7. Lead (as Pb), mg/kg	10.0

In India most of the agar industries are following preacid treatment method for extraction of agar i.e., the sun dried seaweeds washed with water to remove the sand and other impurities. The seaweeds are then treated with hydrochloric acid. The acid treated seaweeds

are washed with water to neutralise. Then the seaweed is boiled in the agar extraction vessel (agar digester) under steam pressure for 1-2 hours. The gel is collected in trays and kept in the freezing unit for 24 hours at low temperature. After thawing, the agar sheets are bleached, sun dried and marketed. The agar produced by preacid treatment usually have low gel strength. In foreign countries like Japan, Thailand and China several methods of alkali treatments have been developed to improve the gelling ability of agarophytes and particularly ***Gracilaria*** species. It was found ***Gracilaria*** agar gels are superior in gel strength than ***Gelidium*** agar due to alkali treatment.

As gel strength is the most important physical property for commercial agar, reducing the sulphate content is beneficial to increase gel strength. The most effective methods of desulfation is alkali treatment. The bacteriological agar grade should be neutral and contain the least possible amount of sulphate. The demand for agar as culture media is so high that prices increased considerably. The agar gel is more suitable as culture medium for diagnostic test and tissue culture.

Naturally the plant ***Gelidiella acerosa*** contain very good quality of agar with low sulphate content. However the pretreatment of ***Gelidiella acerosa*** with low concentration of sodium carbonate for 30 minutes gives high gel strength upto 700gm/cm^2 whereas the gel strength of agar by acid pretreatment was only 250 gm/cm^2. The sulphate and ash content in alkali treated seaweeds are found in low quantity. In general the agar extracted by acid treatment process shows the gel strength ranging from 100-150 gm/cm^2 in ***Gracilaria*** spp and 200-250 gm/cm^2 in ***Gelidiella*** spp. So care should be taken at various stages in agar production particularly at the stage of pretreatment before boiling the seaweed to improve the gel strength of agar.

The cost of raw material of ***Gracilaria edulis*** is cheaper than the ***Gelidiella acerosa*** and hence most of the industries are utilising the ***Gracilaria*** spp and produce low quality (food grade) agar. As far as ***Gracilaria*** is concerned, the seaweed treatment prior to the extraction is very important as it will influence the sulphate content of the agar. There are three types of processing methods with alkali treatment.

In the first treatment, ***Gracilaria*** seaweed is submerged in moderate concentration of NaOH solution for 5 days or more at room temperature. The volume of NaOH is about 15 to 20 times that of the raw material (dried). By this method the yield and the gel strength of agar are high. The demerits of this method is that it is long time processing method and require large quantities of NaOH and also seaweed immersing tanks. This method is suitable for delicate ***Gracilaria*** plants.

In the second type, the concentration of NaOH is still low but the seaweeds are treated at 60-85^0 C for 16-20 hrs. This is suitable to almost all the species of ***Gracilaria.*** This method also improves the yield and gel strength of agar to a maximum level.

The last method is usually with a very low concentration of NaOH at a higher temperature (90^0-95^{0}C) for 1-3 hrs. The concentration of NaOH and the temperature are dependant on the quantity and texture of ***Gracilaria*** spp. The higher temperature and lower concentration of NaOH are used to treat the seaweeds with hard texture and large quantity. A lower temperature and a higher concentration of NaOH are much more suitable to those seaweeds with delicate texture and poor quality.

In general the following points have to be taken into account to get maximum yield of agar and gel strength for exporting them to earn a very good foreign exchange to our country.

(a) Selection of good grade raw material

(b) **Acid Treatment:** The acid concentration and treating time should be considered.

(c) **Alkali pretreatment:** The alkali concentration, temperature and time of treatment should be considered for better yield and high gel strength of agar.

(d) Neutralization after alkali treatment.

(e) Extraction temperature and time.

(f) **Bleaching:** The concentration of bleaching agent and bleaching time should be strictly controlled. The agar sheets should be thoroughly washed after treating with bleaching agents.

(g) Drying should be kept at lower 60°C to prevent depolymerization of the products.

Truth of the Ocean

K. Diwakar and K. Muniyandi
Regional Centre of Central Marine Fisheries Research Institute,
Marine Fisheries - 623 520, Ramnad District, Tamil Nadu.

Introduction

It is not too much to say that water is life. Our planet is the only one in our entire solar system which has been blessed with water and ocean. You may recall that our earth is often called ' a watery planet' as 71% of the earth's surface is covered by the oceans with all the adventures and challenges they provide both to man and science. Today, parts of the world ocean are intensively exploited for recreation, military purposes, commercial shipping, fishing, extraction of gases, oil and other mineral resources.

Physical Features

The oceans form the biggest store house of world's water resources. In fact, the oceans constitute about 97% of the world's water resources and the remaining 3% is in the form of ice in the polar regions of the earth. The average depth of ocean is about 3,800 meters. But when compared with the earth's diameter of 13,250 kilometers, the ocean is actually a very thin film of water covering the earth's crust. All the oceans are inter connected by straits and they are saline (salty water) in nature. The pressure within the ocean varies from 1 atmosphere at the sea surface to about 1000 atmosphere at the greatest depth. There are five oceans on the earth. These are: Pacific ocean, Atlantic ocean, Indian ocean, Arctic ocean, and Antarctic ocean. The pacific ocean is the biggest and deepest ocean of all. Actually, the pacific ocean is so vast that it can accommodate all the five continents of the earth. The maximum depth of pacific ocean is 11,033 meters, at Marina Trench, halfway between the islands of Guam and Yap in the pacific ocean. In fact, this depth exceeds the height of Mount Everest which is 8,848 meters.

Some comparative features of the major ocean basins

Ocean	Area $10^6 km^2$	Volume $10^6 km^2$	Average Depth (m)	Maximum Depth (m)
Pacific	165.2	707.6	4,282	11,033
Atlantic	82.4	323.6	3,926	9,200
Indian	73.4	291.0	3,963	7,460
Arctic	14.1	17.0	1,205	4,300
Caribbean	4.3	9.6	2,216	7,200
Mediterranean	3.0	4.2	1,429	4,600

Mountains beneath the ocean

Oceanic depths extend to over 11,000 meters, but most of the depth lies between 3,000 meters and 6, 000 meters. What lies at the bottom of oceans is the hills, valleys, plains and plateaus just as they occur on land. A mountain range is present in the bottom of the Atlantic ocean, called 'Mid Atlantic Ridge'. This mid Atlantic ridge is about 3 kilometers high and about 65000 kilometers long and it encircles the earth like a belt.

Origin and composition of seawater

The sea water contains many inorganic salts and organic matter. It has accumulated them during the course of billions of years by soil erosion, decomposition of organic matter and the condensation of water vapour from the atmosphere. Ocean is also a resource for many important minerals such as sodium, potassium calcium, nickel, cobalt, magnesium etc., "Nodules" which are present in certain areas of sea bottom are rich in nickel, cobalt and manganese metals. It also contains metallic salts of phosphate, silicate, nitrite and nitrate. Dissolved gases and organic compounds derived from living organisms are also present in the sea water . Organic compounds of seawater include fats, oils, carbohydrates, vitamins, amino acids, proteins etc. Scientists think that these compounds are an important source of nutrients for marine bacteria and plankton. There exists an organic cycle right from plankton to biggest animal like whale in the ocean to stabilize its ecosystem.

Upwelling

Upwelling phenomenon occurs when the wind direction drives the surface water away from the coast and it is replaced by water from deeper regions which are colder and nutrient rich. "Upwelling" areas are found along the coast of certain areas. The upwelling of deeper waters provides nutrients for the growth of tiny organisms, which fish and other sea animals eat. Upwelling areas have great fish resources and in fact, it yields half of the world's fish catch. Important upwelling regions include the coasts of Peru and north western Africa. In India, several upwelling areas are identified along the west and east coasts. Bnt, most of them are found within the EEZ. The west coasts of India has been noted to have well-known upwelling areas, generated during southwest monsoon. Most of the areas of upwelled water is found on the sea surface,which enhances the primary productivitiy which is again utilized directly by the herbivorous fishes such as sardines and anchovies or it is consumed by the zooplankton which, in turn are eaten by fishes like mackerel.

What is Guano?

'Guano' are the accumulated droppings of numerous sea birds like "Guanary Cormorant" and others. These accumulated droppings usually float in the seawater. The farmers of countries like Ecuador, Chile and Peru collect these Guanos and use them as organic fertilizer for their farms and get very good harvest. Years of great upwelling resulted in the production of huge quantities of Guano.

El Nino effects

Each summer during Christmas, a warm oceanic current from the north (El Nino means the child Jesus) flows to south, bringing rain and warm temperatures. When this phenomenon occurs warm water flows further south than usual, and eventually reaches Chile coast preventing cold nutrient-enriched water from upwelling. This effect is particularly severe along the Peruvian coast. This results in dramatic reduction in planktonic growth, reducing the fish population and leading to the death of millions of sea birds. The real reason for the occurrence of El Nino at random intervals remains unexplained and hence dates/periods of further occurrences can not be forecast. El Nino happened six times during this twentieth century and it is associated with anomalous behaviour of the atmosphere and oceans in other parts of the world.

Correlations have been made between El Nino and sea surface temperature anomalies in the western pacific ocean, drought in Sahelian zone of north Africa, cold winters in the USA and failure of monsoon rains in the Indian sub-continent.

Continental shelf

The continental shelf is the submerged land at the edge of the continents. It begins at the shorelines and gently slopes under water to an average depth of about 130 meters. The width of the continental shelf averages 75 kilometers. In Arctic it measures only 1.6 kilometers or less. In total, continental shelves accounts for about 8% of the ocean's surface area. The shelf collects sediments (sand and mud) which is carried by rivers and deposited into the ocean. Continental shelves harbours the maximum variety and quantity of marine organisms. The main reason being its fertility due to the addition of various nutrients from adjacent terrestrial run off.

Continental drift: Tectonic plates of the continents

The positions and shapes of the land masses of the earth, the size and shape of the intervening oceans were not the same some 200 million years ago. They have been changing continuously over the years. In 1912, a German astronomer and meteorologist, Alfred Wegener, developed and propounded a theory that about 200 million years ago all land masses of the earth were nestled together in one single super-continent called Pangaea (from Greek, meaning "all land"). The evidences given by him for his theory, were ambiguous and most scientists during his time were unconvinced. But in 1968, the reports of the ship, the Glomar challenger based on her ocean floor exploration beyond 7,000 meters depth on both sides of the Mid-Atlantic Ridge firmly supported the concept of seafloor spreading and continental drift. As such, the African continent is drifting northward on a collision course with Europe slowly closing the Mediterranean sea.

The Atlantic ocean is becoming wider at the expense of the Pacific Ocean. The south Atlantic is widening about 3 cm each year, where as Pacific ocean is shrinking some what faster. India and Australia continue to creep northward, slowly changing the shapes of the ocean basins they border. The present day occasional violent earthquakes are resulted by the collision of continental plates with one another due to continental drift.

Deep sea hot springs

Deep-sea hot springs were recently discovered along the axes of ridge near Ecuador. It supports unique communities of deep-sea animals. Dissolved hydrogen sulphide emerging from seafloor cracks is used as an energy source by chemosynthetic bacteria. The bacteria in turn source of nutrition for dense animal populations clustered around these springs. Water temperature sometimes exceeds 100 degree Celsius at hot spring sites in sharp contrast to the near uniform temperature of 2 degree Celsius abyssal water just a few meters away.

Exclusive Economic Zone (EEZ)

To utilize meaningfully the ocean resources for supplementing the fast dwindling resources of the land, the issue of extending the jurisdiction over the ocean areas remained a subject of discussion for several years. After years of deliberations, a new regime was established by the United Nations Convention on the Law of the sea (UNCLOS) in 1982, which has been signed by many countries, including India. Finally the Law of the sea convention came into force with effect from November 1995. With this, the way is cleared for exploitation of sea resources, both of deep sea as well as the near shore areas. The UNCLOS has declared an Exclusive Economic Zone upto 200 nautical miles with respect to the shorelines. India has nearly 2.02 million sq.km of the sea area along the west and east coasts and the Andaman sea, as the EEZ for her oceanic exploitation.

Icebergs: Titanic disaster

Ice bergs are a great hazard to shipping which was highlighted by the Titanic disaster on 14 April 1912 in the north Atlantic Ocean. Icebergs can be as much 70m high (above the sea level) and 1,000m long. The volume of an iceberg is 90% while the depth underwater and height above varies with type and shape of the iceberg. Antartic icebergs present a significant threat to regular shipping routes only near the tip of South America. Establishment of an ice reconnaissance and warning service, now known as International Ice Patrol, was one outcome of the lessons of the Titanic disaster. The patrol observes seaice and icebergs, particularly in the shipping lanes, and keeps the ships informed of the ice conditions twice daily by radio.

Tides

The periodic rise and fall of the sea constitutes tides. Tides are caused primarily by the gravitational pull of the sun and the moon. The cycle of tides is every 24 hours and 50 minutes which is the interval between the consecutive meridian passages of the moon, that is, each day tides occur 50 minutes later than on the previous day. There are areas with a 24 hour (or daily) i.e., one high water and one low water a day, a 12 hour period called a semi diurnal (or half day) tide with two high and two low waters a day, also a 6 hour period with four high and four low waters a day. Semi diurnal tide is most common and this form of tide occurs obtains along the coasts of the Indian sub continent.

Feats of some marine organisms

Myriads of biological wealth originated from the sea and support the human beings in many ways. Single celled plant and animal members like diatoms, protozoans to mammals like blue whales are inhabiting the sea as their niche. A blue whale calf initially weighing 3 tons at birth increases in body weight of 23 tons after seven month at an average weight gain of almost 100 kg a day.

This kind of astonishing growth rate is possible only with the abundant supply of high fat milk. Cetacean milk has the fat content of 25 to 50% (Cow's milk contains 3 to 5% fat). The daily milk yield of a baleen whale is estimated to nearly 600 liters. Marine mammals have long gestation period ranging from several months to a year. Cestaceans and Pinnipeds (eg. Walrus) occupy the colder waters and produce more milk with high fat content. Whales and Pinnipeds like Walrus mate only once in every two or three years.

The periodic seasonal movements exhibited by some animals is called migration. Some of the marine organisms too exhibit migration for an astonishing distances. Thus gray whales spend the summer in the Berring sea and the adjacent areas of the Arctic region. As the formation of sea ice starts in the Arctic waters in autumn, the gray whales migrate as far as 18,000 km to the warm protected coastal lagoons of Baja California by late January. In the protected waters, the whales mate and the pregnant females give birth to their calves. By early spring, they again migrate northwardly to Berring sea. Similar long distance migration are noted in marine turtles, eels, tuna and salmon also.

Conclusion

Similar wonders and concepts are abundant like the extent of the ocean itself. As human investigation progresses, new knowledge and wonders of the ocean may reveal astonishing facts about the ocean to future generations. Hence explore the ocean continuously.

Islands around Gulf of Mannar

M. Anand & J. Anandan
Regional Centre of Central Marine Fisheries Research Institute,
Marine Fisheries - 623 520, Ramnad District, Tamil Nadu.

Island is a body of land smaller than a continent and surrounded by water. There are about 21 islands in Gulf of Mannar on the South eastern coast of India extending from Rameswaram island on the north and Tuticorin on the south between latitude 8° 50' – 9° 15' N and longtitude 78° 13' - 79° 14' E. These islands and the sea around them upto 3.5 – 5 fathom depth, has been notified as a National Park under the provisions of the Wild Life Protection Act 1972. Gulf of Mannar alongwith islands was declared as the first Marine Biosphere Reserve (GOMMBRE) in South east Asia. GOMMBRE was set up on 18-02-1989 jointly by Government of India and State of Tamil Nadu. Islands around Gulf of Mannar houses a rich variety of fauna and flora that derives her the term "Biologists Paradise". All 21 islands are coral islands of fringing and patch types covering an area of 623.12 hectares.

Shingle Island

Shingle island has an area of 12.69 ha. Earlier Singalese fishermen used to land and stay here during their fishing operation. Hence it was called Singala thivu, later termed as Shingle Island. Its northwest and northeastern shores are sandy, the southwestern shore is found full of dead corals. This island is 4 kms away from Pamban. This area is good for snorkelling.

Krusadai Island

Krusadai island has an area of 65.80 ha. This island is 3 km away from Pamban. The nearest land is Kundugal point 500 mt away . The southeast part of the island is sandy, while the northern part is muddy with marshy vegetation. Western part of the island is covered with mangroves and the southeastern part of the island is with livecoral reefs. Main inhabitants of the island are Field rats, Birds, Moths, Beetles, Garden lizards and the rare Hemichordate representative Balanoglossus. Since the island having many marine species of animal life, it is called as "Marine Biologists Paradise". Fishermen camp here for few days for fishing activities.

Pullivasal Island

Pullivasal island has an area of 29.95 ha. The island is about 5 kms from Mandapam. This island has to be approached from Poomarichan island by crossing the channel separating the two islands. Eastern and southern shores are sandy while the northern part is muddy and marshy.

Poomarichan Island

Poomarichan island covers an area of 16.58 ha. It is situated 5 kms away from Mandapam. It is almost like a horse-shoe shaped island. It is a marshy island, wooded jungle with the water area enclosing a continuous reef. Fishermen from Mandapam and Pamban collect shells from this island.

Manoli Island

Manoli island covers an area of 25.90 ha. It is situated at a distance of 6 kms from the Mandapam camp mainland. Extensive reefs with live and dead corals are present on the southern and northern sides. The island has lagoonal pools and open mud flats. The lagoonal area is margined shorewardly by mangroves and seawardly by live corals.

The northern and southern beach ridges are separated by an area of Thespesia wood land. Large number of birds visit this island during March to September. Fishermen and seaweed collectors are staying for a stretch of six or seven days with their families.

Manoliputty Island

This island covers an area of 2.34 ha., and is situated 6 kms away from Mandapam camp. Bushes are abundant and patch corals are found around this island. It is a very small island separated from the nearby Manoli island by an extensive sand flat. Fishermen are staying here for collecting seaweed and live shells.

Hare Island

This island is largest of all 21 islands covering an area of 129.04 ha. It is 7 kms away from Mandapam camp. Shore is sandy. Dense coconut gardens are found in this island. Human interference has brought some cattle, goats and monkeys to the island. Very good assemblage of coral reefs are found around the island. Tolerably good drinking water is present.

Van Island

Van island covers an area of 16 ha. and is situated 6 km away from Tuticorin new harbour mainland. Construction of break waters in Tuitcorin harbour in early 70's caused the depletion of sediment from the upstream side in the northwest direction to 1.62 km towards the mainland. Reef of Van island is non-elongated with sharp corners and their developments are extensive on the south, southeast and northeast of the island. Fishermen from Taruvaikulam and Tuticorin visit the island for collection of coral rubbles from the shallow water zone around the island.

Koswari Island

This island covers an area of 19.50 ha. and is situated 7 km away from Tuticorin mainland. The whole island is covered with xerophytic vegetation . The reef area is small. The average depth of lagoon is about 2.5 m. Branching corals are seen at a distance of 200 meters from the shoreline, then massive type of the corals heads and dominate with increase in the depth.

Vilangushuli Island

This island covers an area of 0.95 ha. and situated about 15 km from Tuticorin mainland. This island reef is narrow and elongated . It is a very small island , completely strewn with coral rubbles , some bushes and grasses that are seen towards the middle of the island.

Kariyashuli Island

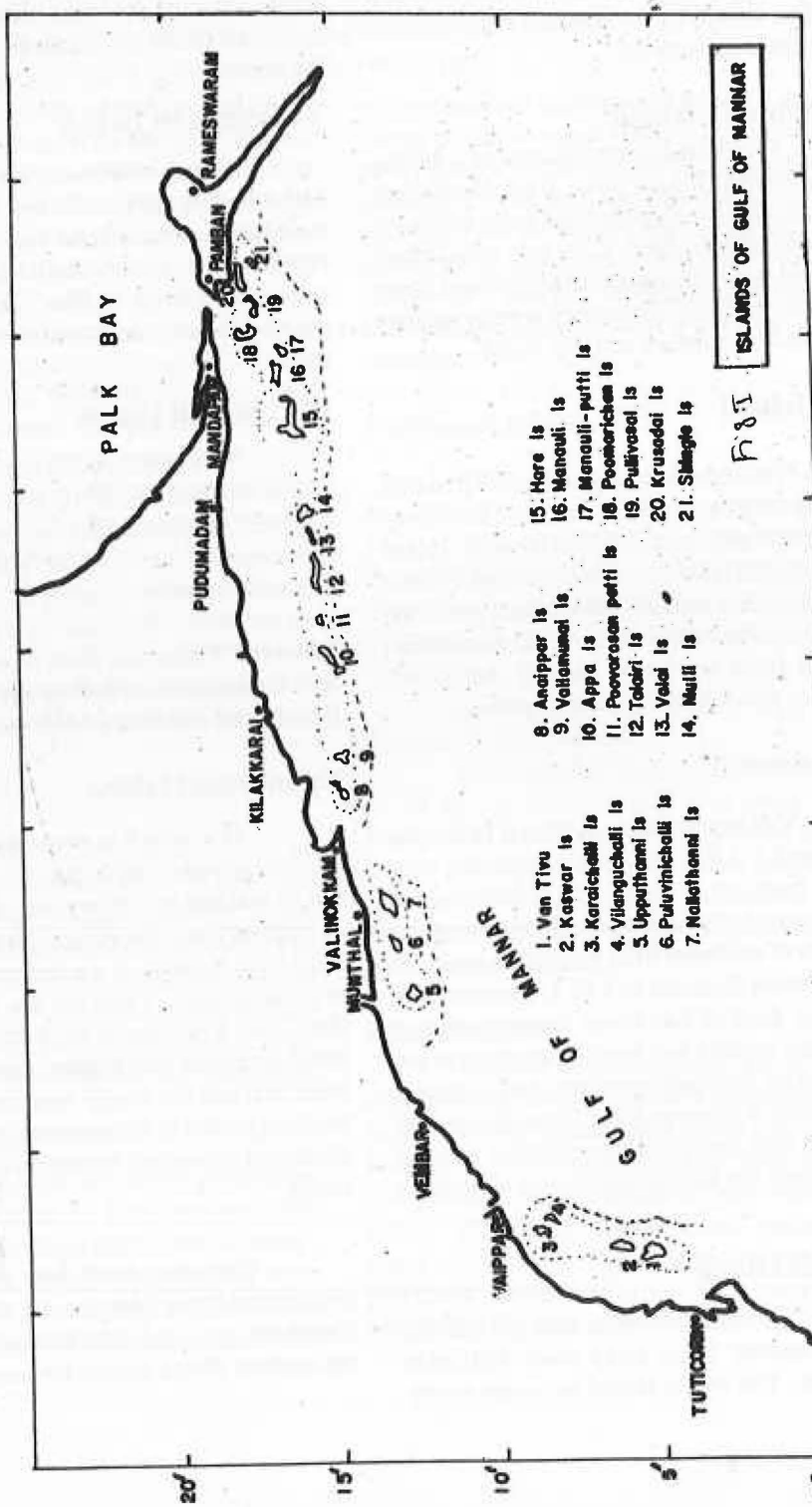
This island covers an area of 16.46 ha. and is situated about 15 km away from the Tuticorin mainland. The reef area is small and depth exceeds 3 m in certain places. This island had best formed reef among all islands and now it is no more best due to exploitation for limestone. Fishermen from nearby villages are here for operation of bottom-set gill nets . Men from Ervadi collect seaweeds around this island.

Upputhanni Island

This island is about 29.94 ha. and is situated opposite to Mukayur village. This island can be reached by vallam (motorised canoe) in 25 minutes from this village. The island is 8 km away from Vembar. It is a fairly big with plenty of coral rubbles. There are few trees here and there, with a number of tall bushes. The entire island is covered with grasses. Several fishermen from Naripaiyur camp here to quary coral boulders buried in the centre of the island , thus disturbing the natural formation of corals in the island.

They also camp here frequently for commercial exploitation of the seaweed ***Gelidiella*** sp. and Gracilaria sp. growing in the shallow waters around the island.

ISLANDS OF CULF OF MANNAR



Nallathanni Island

This island has an area of 110.00 ha. and is situated in 2 km from Mundel, a placenear Valinokkam. Potable water is available. This is one of the biggest island having about 4000 coconut trees, palmyrah and other woody trees. A temple of Muniswaran god is present. People from mainland used to visit the temple on every Tuesday and Friday of the week. A good number of fishermen frequently visit this island for fishing operations. They are also engaged in algae and live shell collection. Coral reefs and coral boulders are available all around the island at a distance of 0.5 km on the southern side and very near on the northern side.

Puluvinchalli Island

This island has an area of 6.12 ha. and it is 18 km away from Vembar. It has a good sandy beach. A fairly good portion of the island has thick vegetation. Few Thespesia trees are available on the eastern side. Fishermen from Kilakarai frequently visit this island, staying for a week for lobster fishing. Some people are engaged in algae and live shell collection. This island is surrounded by live coral all around except for a small stretch on the eastern side.

Vallimuni Island

This island has an area of 6.72 ha.,. It is 9 km away from Kilakarai. It is a sandy island with shore strewn with coral rubbles. This island is completely covered with Acacia trees and tall bushes of ***Zizyphus jujuba***. The southern corner of the island has been affected due to wave action. Fishermen visit this island for lobster fishing. Women and boys are engaged in algae and live shell collection. Live coral reefs are available in southwestern corner at a distance of 200 m from the shore. Dead coral reefs are available all around the island.

Poovarasanpatti Island ('Kilangan Paar')

This island is 0.25 ha. in area and is visible only during low tide and fully submerged during high tide. Live corals are available in this area upto a distance of 100 m except on the northern side. Collection of seaweed is the only activity of the fishermen here.

Other islands

Appa island has an area of 28.63 ha. and is situated 8 km away form Kilakarai. Talairi island covers an area of 75.15 ha. and is in 15 km away from Kilakarai. Valai island has an area of 10.15 ha. and is 15 km away from Kilakarai. Trap-net fishing is intensive in and around this island. Mulli island covers an area of 10.12 ha. and is situated about 15 km from Kilakarai. Bushes are found throughout this island.

Bottom Trawling - A Potential threat to the Ecology and benthic communities of gulf of mannar

P.Jayasankar, M.Anand and J.Anandan
Regional Centre of Marine Fisheries Research Institute,
Marine Fisheries -623 520, Ramanathapuram District, Tamilnadu.

It is now widely appreciated that an important aspect of protecting fish stocks is the conservation of the habitats and animal communities on which those stocks depend. Over the years, fish catching techniques and devices have undergone remarkable variations, every time improving their efficiency. Trawl net exploits fish and other organisms from the bottom of the seas. Bottom trawls are sometimes referred to as bulldozers mowing down fish and destroying the structure that provides fish stocks with the necessary environment.

Trawl ground gear can penetrate upto 6 cm into bottom sediments and otter boards have been found to dig into the bottom to a depth of 0.3 m. Obvious mortalities ae generated when benthic species are brought to the surface and then discarded. Not the least of these are mortalities due to increased predation following the redistribution of benthic species to surface waters and on the seabed.

The effects of physical disturbance processes on marine benthic communities remains an issue of considerable theoretical and practical importance, particularly with respect to the impact of fisheries activity and possible conflict with wildlife conservation objectives. Possible effects of trawling on benthic resources include,

- Changes in sediment structure.
- Changes in in-faunal and epi-faunal community structure
- Survival of animals retained by the cod-end and those escaping through the meshes of the cod-end
- The feeding behaviour of predators and scavengers that aggregate in trawled areas

One of the major environmental problems associated with bottom trawling is the practice of discarding non-target species into the sea to save holding space for the more valuable target species. These 'discards' finally die out, though a portion of them may form food for scavengers of the sea, thus contributing to the trophic web. Global discards, especially in shrimp trawl fisheries are provisionally estimated at 27 million t with a range from 17.9 to 39.5 million t. Shrimp trawl fishery, particularly for tropical species, were found to generate more discards than any other fishery type and account for just over one-third of the global total. It may be noted that species of currently low economic value may become important target species in the future.

Many of the marine invertebrates, which constitute the 'non-target' species in trawl catches, have sensitive life history tactics. They have generally low reproductive rates and adult survivorship is critical to maintain healthy populations. They are seriously affected by by-catch and it is imperative that adequate "brood stocks" be maintained in natural conditions. The invertebrates are broadcast spawners and to ensure fertilization, males and females must be surprisingly close together when they spawn (the distances are often in the order of 1-3 m) which implies a need for

* Present address: CMFR Institute, Cochin - 682 014.

a high density of breeding animals. This is particularly important to sessile animals, such as sponges, hydroids, bryozoa, tunicates, etc.

Gulf of Mannar Biosphere

Biosphere reserves are protected areas of representative environment. The Gulf of Mannar is one of the marine biospheres situated along the coastline of east coast of India and Srilanka (8°46' - 9°14'N; 78°9' - 79°41'E). It has an area of 10,500 sq. km and 21 islands are situated in this biosphere. The Gulf of Mannar is one of the biologically richest and important habitat for marine algae, sea - grass, coral reef, pearl banks, sacred chank bed, fish and shelfish resources, mangrove endemic and endangered species. There are approximately 3,600 species of flora and fauna in this ecosystem. The 21 islands are declared as national marine park by the Government of India and state of Tamilnadu in 1986 for the purpose of protecting marine wildlife and its environment.

Bottom trawling

Mechanized trawling industry, which came into vogue during early '70s, has expanded considerably, especially due to the remunerative export demand for shrimps. In the later years, other items were also added to the list of "target groups" of trawlers, including lobsters, cephalopods, swimming crabs and commercial sized finfishes in the fish trawl nets. In the Gulf of Mannar, the trawling grounds lie between 79° and 79°25'E longitude and 8°46' and 9°10'N latitude, about 20-26 km away from the coast. Sea bottom is largely muddy or sandy, though some areas have coral structures. Depth of operation ranges from 20 to 42m. Fishing takes place round the year in the Gulf of Mannar. During May-September when the sea will be rough due to southwest monsoon, trawlers operate in the daytime. During October-April, about half of the trawler units engage in night fishing, while the other half go for 2 night - 1 day fishing (locally known as thangal fishing). About a hundred trawler units are operating in the Gulf of Mannar from the two main landing centres, Pamban and Mandapam.

Effects of trawling on benthic ecosystem

Investigations world over have indicated apparent adverse effects of trawling on the sea bottom, epibenthic assemblages, seagrass beds and on the nutrient enrichment of coastal waters. The rate of decline in the catches of commercially important green tiger shrimp in the Gulf of Mannar could be due to the indiscriminate destruction of seagrass beds by trawling, which form a critical biotope of this prawn. Comprehensive information on the impact of bottom trawling on sea bottom, life cycles of non-target species, post-harvest loss and in-edible biota destruction, the migration of various species and prey-predator relationship of major component species is essential.

Realizing the importance of this issue, particularly in the context of conservation of national parks, the Ministry of Environment and Forests (MOE & F), Government of India have sanctioned a research project to study the direct and indirect impact of bottom trawling on the coastal marine living resources and to assess economic utility of non-target groups dislocated by fishing, with the senior author as the Principal Investigator.

R & D efforts

Before the initiation of the MOE & F-funded project, the senior author have made preliminary investigations on this issue during 1992-95. The study indicated that the total quantity of non-target groups landed by trawlers was greater in the Palk Bay due to increased fishing effort, but the catch rate of this benthic biota was relatively greater in the Gulf of Mannar.

Among the major objectives of the MOE & F funded project, which was initiated in 1998 include,

Collection of data on commercial trawling in the Palk Bay and Gulf of Mannar for assessing the exploited resources and the extent of disturbance on sea bottom

Study of dynamics of food chain linkages of exploited bottom fauna

Evaluation of the quantity and quality of non-target groups dislocated by trawling

Study of hydrology and productivity of trawling grounds.

Trawl catches are broadly classified into TARGET GROUPS and NON-TARGET GROUPS. The target groups include commercial sized finfishes, prawns, lobsters, crabs and cephalopods. The non-target groups include low volume ground fishes, undersized shrimps and inedible biota. In the commercial trawl catches from the Gulf of Mannar, target groups forms 66-92% and the non-target groups 8-34%. Finfishes form almost 95% of the target groups. Major groups of finfish in that order are clupeids, silverbellies, carangids, goatfishes, croakers, seerfishes and elasmobranchs. Of the non-target groups, predominant species are low volume ground fish, stomatopods, echinoderms, gastropods, in-edible. crabs, undersized shrimps and bivalves.

Study on the seasonal occurance of trawl components revealed that target groups are abundant (400-650 t) during January to March, while non-target groups are abundant (30-45 t) during July-September and in December. A close look at the data on seasonal variation in trawl catch and effort at Pamban in 1998, showed that with the increase in effort, the catches of target groups declined and non-target groups registered a relative increase. This could prove critical, as no economic advantage is achieved by way of increasing trawling effort in the Gulf of Mannar, at the same time the less economic species are dislocated, which could impart disastrous effects on the delicate trophic equilibrium of this ecosystem.

In a recently conducted experimental trawling in the Gulf of Mannar off Mandapam (5 km off the coast, 7 m deep), seaweeds and seagrass formed about 85% of the catch. It is not surprising that many of the commercial trawlers, fishing in waters below 10-15 m depth, would net in huge quantities of these plants and dislocate them. Mere observation of the catch landed on shore would not 0 reveal the real picture, as they would unload the sea grass back into the sea. As mentioned earlier, these plant beds are vital for many commercial important groups of organisms to survive and their destruction would bring about irrepairable damage to sustained production from this coastal ecosystem.

Conclusion

The irrepressible quest for more and more quantities of target groups, especially prawns, has resulted in several new innovations in fishing methods. There is a possibility that extensive bottom trawling could disturb the benthic biota, paving the way to recruitment hazards and bottom diversity degradation. It is imperative to conduct serious study on the post-harvest loss and non-target group destruction, biological interactions and survival in the marine benthic ecosystem. An attempt is already on to generate adequate data base with a view to formulating suitable management measures for a sustainable resource utilization and for controlling indiscriminate destruction of benthic non-target biota.

Marine Turtles of Gulf of Mannar, Tamil Nadu

P. Nammalwar & M. Rajagopalan
Madras R.C. of Central Marine Fisheries Research Institute
Madras - 600 006.

Introduction

Marine turtles have very long geologic history. They were common in the Cretaceous, 130 million years ago and their fossil record extends back atleast 200 million years. They lived together with dinosaurs and have survived the giant plesiosaurus and Ichthyosaurus. All present day genera and species originated in the period from the early Eocene to the Pleistocene between 60 and 10 million years ago. Together with the marine snakes and iguanas, they are the only surviving seawater adopted reptiles. Their distribution is mostly tropical and suptropical and they depend on the land only during the reproduction period.

India has been playing a major role in the protection and conservation of endangered and vulnerable species of animals and plants. Wildlife ecology has received great attention in the terrestrial sanctuaries and parks. Great interest is now focussed on the study of marine turtle resources in our Exclusive Economic Zone to develop proper conservation and management measurers.

The turning point has been the promulgation of the Indian Wildlife (Protection) Act 1972 wherein all species of marine turtles have been included as endangered species in Schedule - I and are thereby completely protected. They are also been incorporated in Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES).

The marine turtle fauna of India

Marine turtles are known to inhabit all along the coast of India including the Gulf of Mannar, Lakshadweep and Andaman and Nicobar Islands. Five species inhabit the Indian waters and are capable of taking long distance migration. In the order of abundance they are the olive ridley ***Lepidochelys olivacea,*** the green turtle ***Chelonia mydas,*** the hawksbill ***Eretrmochelys imbricata,*** the loggerhead ***Caretta caretta*** and the leather back ***Dermochelys coviacea.***

Lepidochelys olivacea (Olive ridley turtle)

This is the most common marine turtle in Indian waters. Very heavy concentration of this species occurs in Orissa Coast. Mass nesting occurs in a stretch of 15 km Gahirmatha beach during January - March every year. This species nests both in the east and west coasts of India, as well as in the Bay Island.

Chelonia mydas (Green turtle)

This is the largest species found in the Indian waters. It occurs in the west and east coasts of India, Lakshadweep and Andaman & Nicobar Islands. The name green turtle indicates the green colour of the fat. It is predominantly herbivorous and feeds on seagrass. This species was highly priced and there was a directed fishery for the green turtle in the 1970s in the Gulf of Mannar area.

Eretomachelys imbricata (Hawksbill turtle)

It is comparatively a small turtle and numerically less abundant in the Indian waters than the other species. It is reported from Lakshadweep, southeast coast, Tamilnadu and Andaman & Nicobar Islands. It feeds mainly on sponges, crabs and molluscs. As it frequently feeds on poisonous marine animals, the flesh of this species is often reported to be poisonous.

Caretta caretta (Loggerhead turtle)

This species is reddish brown in colour and is characterised by a large head in relation to the body size. In India, it is recorded only from the Gulf of Mannar. It is a carnivore, feeding on crabs, fish and other benthic animals.

Dermochelys coriacea (Leatherback turtle)

Individuals of this species attain a weight of 500 kg. A thick leathery tissue covers the bones of the shells and hence the common name. Indiscriminate poaching of eggs in the 1970s caused the disappearance of this species in the mainland coastal waters. However, they occur in pristine beaches and adjacent waters of Little Andamans and Nicobar Islands.

Marine turtle fishery in the past (Gulf of Mannar)

Turtles were caught from Gulf of Mannar and Palk Bay from very ancient time. An estimate by the CMFRI during sixties that an average about 3000 to 4000 turtles were landed every year between Pamban and Cape Comorin. In the Palk Bay the fishery was of a much lower level and about 1000 turtles were landed annually between Rameswaram and Mimisal. The main fishing centres in the Gulf of Mannar were Pamban, Kilakarai, Tuticorin, Ovari, Kuttankuli, Periathslai and Cape comorin while along the Palk Bay, the centres were Rameswaram, Tondi, Tirupallakudi, Devipattinam and Pamban. The green turtle constituted about three fourth of the total catch. Olive ridley and loggerhead formed about 20% of the catch. The catch was mainly sent to Tuticorin from different places of capture. The assembling centres for turtles in the Gulf of Mannar are Rameswaram, Kilakarai and Tuticorin and on the Palk Bay coast Tondi and Pamban. At these places special pens were constructed in the sea close to shore for keeping the turtles alive. Turtles were caught by special type of wall nets made of fibres of Acacia or of cotton yarn. Two types of nets known as 'Pachu Valai' and 'Kattivalai' were used each requiring between 5 to 8 men for operation. There was a regular trade of olive turtles between India and Sri Lanka until recently. The meat and shell were exported for food and ornamental work. This large scale exploitation of this marine animals have resulted in their depletion in our waters and almost reached a state of endangered status. Thanks to legal measures recently adopted that this "living fossils" are getting relieved of exploitation pressure, though clandestine captures is still going on at certain places.

Present status

At present all the five species of turtles occurring in Indian seas are protected as they are placed in Schedule - I of the Indian wildwife (Protection) Act 1972 as per the Amendments made to the Schedule in September 1977. India abides by the Convention of International Trade in Endangered species of wild fauna and flora (CITES) which prohibits the trade in turtle products by member countries. In June 1981, India became a party to the Bonn Convention on the Conservation of Migratory Species of wild Animals. Some of the marine habitats such as coral reef areas in the Gulf of Mannar, form the feeding grounds for turtles, None of the five species are endemic and may undertake long migration to feeding and breeding grounds often across international boundaries.

The work of the marine turtle project of Central Marine Fisheries Research Institute has created awareness in Tamilnadu and adjacent maritime states in developing and enlarging conservation programmes for marine turtles.

Incidental catch

A major threat which still persists is the incidental catch of marine turtles in fishing gears like trawl net and gill net. In India the total number of mechanised craft has increased from 19, 210 in 1980 to 57, 706 in 1995. Almost, the entire fishing fleet exploit the inshore area <50 m depth exerting enormous pressure on the living resources.

The Central Marine Fisheries Research Institute besides its headquarters has 12 research centres and 30 field centers along the coast of India from where data on exploited marine fishery resources from artisanal and industrial sectors are being collected and evaluated. The National Marine Living Resources Data Centre (NMLRDC) also collects data on the incidental catch of marine turtles in all the fish landing centres by designating code number for the five species of marine turtles.

From the data thus collected on the incidental catch in all the maritime states in India during 1985-95, it could be observed that 335 marine turtles were incidentally caught all over the Indian coasts. It is estimated that 17.8% of the incidental catch was by the trawlers and 76.5% by the gill netters.

The incidental catch appears to have sharply decreased considering the large scale capture in earlier prior the enforcement of wildlife protection Act. The reasons for the decline despite increase in the number and efficiency of fishing craft are.

i. Awareness of the fishermen to release the marine turtles.

ii. Lack of demand for turtle meat even if brought to the shore due to vigilance by different agencies and

iii Implementation of a 31 km inshore fishing ban on mechanized trawlers to prevent massive annual incidental take.

Management strategies

The Central Marine Fisheries Research Institute (ICAR) in 1984 organized workshop jointly with the Department of Environment, Government of India, Madras Crocodile Bank and Marine Biological Association of India at Madras and a number of suggestions were made for effective conservation and management of marine turtles in India.

They are Habitat Preservation of the present critical areas, already identified vulnerable areas, new areas and the national sea shore system, species preservation through recovery programmes, translocation of nests and setting up of hatcheries, legislation and enforcement of prevalent laws and regulations and future requirements, research pertaining to biology, ecology, transportation of marine turtles. Appropriate legislations be formulated to prohibit use of mechanical or manual means, tools or any destructive instruments to kill marine turtles from the EEZ of the country.

Research

Directed research be undertaken of marine turtles. A planned survey be launched along the Indian coast to identify nesting beaches. Investigations on beach erosion and accretions particularly at the important nesting beaches be intensified. The unique phenomenon of congregation of world's largest population of marine turtles at the Gathimatha (Orissa State) and adjacent regions be immediately studied.

Turtle hatchery programmes be encouraged with adequate financial support. Trials with turtle excluder device in trawl nets may be initiated and the gear modified to suit Indian waters. For future conservation practices it is necessary to explore options of sustained exploitation.

A co-ordinated and centralised mark recovery programme for marine turtles may be initiated. A centralised data bank to facilitate collection and dissemination of information is needed. Research committee for marine turtles in India may be established by the Ministry of Environment & Forests, Government of India. A co-ordination committee be established for the maritime states to facilitate formulation of co-ordinated action plan and its implementation for the conservation and management of the marine turtles resources.

Education, training and extension

Concerted efforts be made on mass education of the public, fishermen and school children. Organised training courses be offered to field officers and extension officers who are involved with marine turtle conservation programme. Extension programme relating to turtle conservation be strengthened and intensified.

Temples around Ramanathapuram

R. Kuppuswami
Neelakandi Street, Ramanathapuram - 623 501, Tamilnadu.

Our country abounds in temples and holy shrines. India has been the cradle of spirituality for millennia, long before the people in other regions of the world thought about such matters as religion, ethics or dharma. The great epics Ramayana and Mahabharatha are filled with details of holy places situated throughout the length and breadth of India. Because Hinduism is pantheistic, there was not only religious tolerance but the tenets of other religions were welcome. The history of Ramanathapuram area is traceable to the Ramayana period. The ruler of this area was called Sethupathi, meaning the lord of the bridge or pass appointed to give protection to the pilgrims passing through here. The ruler accommodated different religions within his kingdom and instituted grants of land, gold and other amenities to shrines of other religions also. Thus grant had been made for the 'dharga' of Abil-kabil (Abd and Cain, sons of Adam and Eve, the first man and woman of genesis) at Rameswaram; the church at the place of martyrdom of Fr. de Britto at Oriyur; for the 'dharga' of Sulthan Syed Ibrahim Vali at Ervadi and for several other places of worship in the district.

Above all, the district gets the most important place in the Hindu pilgrimage route of the country. The rulers of Ramanathapuram have donated 49 villages for the maintenance of choultries, mutts etc. at Kasi (Varanasi). The pilgrimage to Kasi traditionally commences or ends at Rameswaram in Ramanathapuram district. Therefore the Rameswaram Temple, which is one of the 12 jyothilinga temples in the country, is most revered by Hindu pilgrims, next in importance only to Kasi. The rulers of this district were called the protectors of the pilgrims and provided facilities to the pilgrims for travel and stay converging to this place from all parts of the country and abroad. Information about the Rameswaram Temple and some of the easily accessible but important temples of this region are given here.

Rameswaram Temple

According to legend, the idol of Sivalinga in the Temple was installed and consecrated by Sri Rama after the battle in Sri Lanka in which Ravana and his relations were conquered. The idol was made of sand by His consort, Sita. Therefore the linka is known as Ramanathaswami. Pilgrims visiting Kasi and taking bath in the Ganges River there complete their pilgrimage by taking Ganges water from there and doing abhishekam to Sri Ramanathaswami. Hindus consider it the duty to visit Kasi and Rameswaram atleast once in their life time.

The temple is another symbol of the hoary South Indian temple architecture. The immensity of its size is awe-inspiring, especially considering the fact that the nearest stone quarry is away at about 150 km from here. The dimensions of the Temple are 865 ft east-west and 657 ft north-south. There are two big ornamented towers on the eastern and western entrance of the Temple. The outer corridors are famous as the longest ones in the world measuring 640 ft east-west and 400 ft north south. The outer prakara is made up of 1200 sandstone pillars of 30 ft height beautifully sculpted on the Dravidian architecture style.

Pilgrims usually take bath in the sea and also in the 21 wells (theerthams) situated around the Temple. Taking bath in the sea and the 21 wells is believed to rid the bather of disease and expiate sins.

The place called Dhanushkodi is 20 km away from Rameswaram where the waters of Gulf of Mannar and Palk Bay join together. According to legend, the Adhi Sethu, the bridge to Sri Lanka constructed by Sri Rama was broken here by the bow of Sri Rama at the end of the war. This place is considered very holy and a bath in the sea at this place is considered a must.

There is a Devi Temple known as Nambunayaki Amman Temple at a distance of 3 km from Rameswaram. The theertham near the temple is called Sarvaroga Nivarani and is believed to cure chronic diseases. On the way to Dhanushkodi, there is the Sri Kothanda Ramaswami Temple where Vibheeshana did saranagathi (surrender) to God. These two temples are worthy of a visit as part of the pilgrimage.

Rameswaram is well connected by road and rail to all parts of the country. There are several lodging places, choultries, guest cottages near the Rameswaram Temple. A visit to Rameswaram and the Temple would certainly enhance good health and mental peace.

Uppoor Temple

Uppoor is situated at a distance of 30 km north of Ramanathapuram. Legend has it that Sri Rama, during his journey towards Sri Lanka in search of Sita, visited this place and performed pooja to Lord Ganesh in the Temple here, to obviate any hurdles in the journey and for the success of the mission. The temple here is small and has the shrine of Lord Ganesh who is believed to remove the hurdles in the endeavours of the devotees visiting this Temple.

Navapashanam

In the course of his journey towards Sri Lanka, Sri Rama is said to have stopped at the place called Devipattinam. Here he installed the idols of Navagrahas in the form of nine stone pillars in the sea and consecreated them. Because the idols are in the form of stone pillars, this place is known as Navapashanam (meaning nine stones). All pilgrims going to Rameswaram visit this place and offer prayers to the Navagrahas. Devotees who believe in astrology, converge here on all days throughout the year to do poojas and havens to mitigate the malefic effects in their horoscopes.

There is a Temple for the Devi Lokanayaki Amma in this place. The Devi is considered Swayambu, giving the name Devipattanam to this place. The Devi has devotees throughout the country who make it their duty to visit the Temple atleast once a year.

An old Temple of Sri Jagannatha on the seashore at Devipattinam along with the Chakra Theertham has been rebuilt recently. The Sri Thilakeswara Swami Temple in the middle of the village is also very old. The Lord here is believed to grant all boons to the devotees, especially progeny to childless couples.

Thiruppullani Temple

The next point of visit to pilgrims to Rameswaram is the Thiruppullani Temple. Thiruppullani is situated at about 8 km near Ramanathapuram. The bridge to Sri Lanka, built by Sri Rama and his army originates here and it could be seen in the sea at about a kilometer from the shore submerged in the waters. It is said Lord Sri Rama came here and waited for the sea to abate so that the bridge could be formed. As the sea did not abate, Sri Rama was lying in contemplation in Khus (dharbha) grass. Therefore this place is known as Dharbhasayanam. The 'king of the oceans' came in front of the Lord and offered all facilities for the construction of the bridge. The presiding deity of this Temple is Adhi Jagannatha, who was propitiated by Lord Rama himself.

All pilgrims going to Rameswaram make it a point to visit this Temple and offer prayers. There is a huge Aswatha tree in this Temple, which is considered very holy. It is believed that the bark of the tree, taken as a medicine, would cure infertility and other ailments.

This Temple is at a distance of 10 km from Ramanathapuram. This Temple is known as Adhi Chidambaram, because, it is believed that Lord Shiva performed His cosmic dance first here and then only at the Chidambaram Temple. This Temple is said to be nearly 3000 years old. There is a sabari tree in the Temple which is also considered as old as the Temple. Lord Shiva gave darshan here to saint Manickavachakar in the form of a Sahasta Lingam.

The form of Nataraja performing the cosmic dance is considered to embody creation, protection and salvation to the devotees. The main deity in this Temple is the Nataraja made of precious Maragatha stone. The idol is about 5' in height, made of a single Maragatha stone embodying Devi and the ornamental halo (Thiruvasi) around the idol and is said to be most valuable. The idol is kept covered with sandalwood paste throughout the year; the paste is removed only once on the Arudhra Darshanam day (in the month of January) and the idol could be seen without sandalwood paste covering only on this day. Abhishekam is performed on this day to the idol and then sandalwood paste is applied again on the same day. The festival of Arudhra Darshanam attracts huge crowd of devotees to this temple.

Nainarkoil Temple

Nainarkoil lies about 30 km west of Ramanathapuram. The Temple here is several centuries old and is hallowed by tradition. It is said that one of the generals in the army of Malik Kafur visited Rameswaram Temple with his dumb daughter and prayed there for a cure of his daughter. Lord Ramanathaswamy appeared in his dream and ordered him to proceed to Nainarkoil Temple with his daughter. On offering prayer at that Temple, the daughter was cured of her dumbness and shouted 'en-aiyane' (my lord). So the deity here was known by the name Nainar. The Shiva idol in this Temple is facing west which is his Vamadeva form and throughout the year and offer all kinds of agriculture produce with the faith that this brigns prosperity to them for the entire year. Those who visit this Temple are said to be relieved of Rahu dosham.

Sri Rajeswari Temple

Sri Rajeswari is the family deity of the Ramanathapuram kings. This Temple is situated inside the Ramanathapuram Palace. The idol which is of 2 ft height is made of gold, has been installed and consecrated some 400 years back. A Mahameru is installed in front of the deity and all poojas are performed to this Mahameru. The rulers of Ramanathapuram have composed several songs on the Goddess out of their utmost devotion.

Pamban Swami Temple

This Temple is situated at Pirappanvalasai about 20 km east of Ramanathapuram on the Rameswaram Road. Pamban Swami was a saint devotee of Lord Muruga. He was born near this place in the year 1850 and was the ardent devotee of Lord Muruga.As he wanted to perform penance to have dhasan of Lord Muruga he got a chamber of 6 cft of dimension constructed and entered the chamber got it closed and plastered and remained inside offering penance for nearly 40 days. At the end of the penance the lord appeared before him and ordered him to visit his holy shrines in the country. He did so composing 6666 songs in praise of god and performing many miracles during the so journ. After getting repeated darshan of God, he attained Samadhi at Chennai at the age of 83. The place where he first did penance is Pirappanvalasai where the idol of Mayuranathaswami (Subrammanya) was installed in the year 1950 by the disciple of the saint. The temple is located at a serene spot, devotees go to the temple by walk from far off places and stay in the temple for few hours to get peace of mind.

Vellai Pillaiyar Temple

The Pamban Bridge was constructed across the Pamban Channel in the year 1990 providing road link from the Mainland or Rameswaram Island. But most of the travellers using the bridge may not notice the small temple of lord Ganesh situated at the western end of the bridge. The temple is more than 400 years old having been installed there by the Ramanathapuram ruler. The deity is said to protect all the travellers proceeding on pilgrimage to Rameswaram and to fulfil the desires of the devotees visiting the temple.

Sri Thayumanaswami Temple

This Temple is situated in Ramanathapuram itself and is constructed at the place of samadhi of saint Thayumanavar, a jivan-muktha hailing from Tiruchirapalli (Samadhi in the year 1659 AD) The temple and surrounding tapovanam give peace and succour to the devotees visiting it and is a good place for doing sadhana.

There are many temples in and around Ramanathapuram which are hallowed by tradition and granting relief from sufferings to the believers. The existence of these temples in this arid region of the country and drawing devotees from all parts of the country is proof of the cultural and spiritual greatness of the rulers and the ruled.